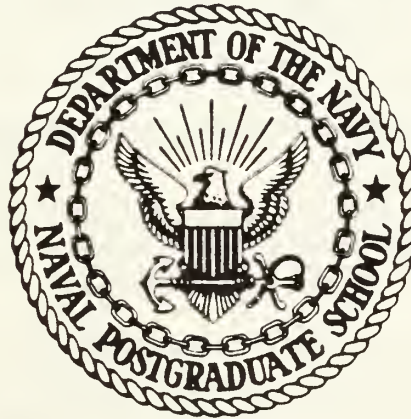


NAVAL POSTGRADUATE SCHOOL

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INVESTIGATION OF TWO FERROMAGNETIC DAMPING
MATERIALS IN CONJUNCTION WITH INITIAL
DEVELOPMENT OF A SIGNAL ANALYZER
INTERFACE PROGRAM

by

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Promising method for the attenuation of shipboard vibration and noise utilizes constituent materials whose composition and microstructure come to absorb energy internally and dissipate it. However, the alloy design of damping materials which possess both significant energy-absorption capacities and also necessary strength levels is difficult. Presently, there are several problems associated with designing a material with high damping characteristics. One of these involves the development of efficient, reliable and reproducible methods for measurement of material damping capacities. In this study, the primary area of interest concerned the development of microcomputer analysis techniques to study the damping response of two iron-chromium (Fe-Cr)-based alloys. The present research utilized a Zenith Corporation Z-150 microcomputer to com-			
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pose programming that captures, stores, and analyzes the damping data produced by various Fe-Cr-based alloy specimens. The computer programming developed in the present research enables an interface of the Zenith Z-150 computer with a Scientific Atlanta SD380Z Signal Analyzer. The programs written will:

- (a) store analyzer screen displays on computer disc media,
- (b) facilitate damping measurements, (c) produce graphic displays of alloy damping characteristics, (d) calculate damping capacities, (e) operate with commercially available hardware and software, (f) provide a programming tool for subsequent researchers to promote further development of this technique.

Investigation of Two Ferromagnetic Damping Materials
in Conjunction with Initial Development of A
Signal Analyzer Interface Program

by

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Submitted in partial fulfillment of the
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DEDICATION

For my loving wife, Marci, and lovely daughter, Felicia.

ABSTRACT

A promising method for the attenuation of shipboard vibration and noise utilizes constituent materials whose composition and microstructure combine to absorb energy internally and dissipate it. However, the alloy design of damping materials which possess both significant energy-absorption capacities and also necessary strength levels is difficult. Presently, there are several problems associated with designing a material with high damping characteristics. One of these involves the development of efficient, reliable and reproducible methods for measurement of material damping capacities. In this study, the primary area of interest concerned the development of microcomputer analysis techniques to study the vibration damping response of two iron-chromium (Fe-Cr)-based alloys. The present research utilized a Zenith Corporation Z-150 microcomputer to compose programming that captures, stores and analyzes the damping data produced by various Fe-Cr-based alloy specimens. The computer programming developed in the present research enables an interface of the Zenith Z-150 computer with a Scientific Atlanta SD380Z Signal Analyzer. The programs written will: (a) store analyzer screen displays on computer disc media, (b) facilitate damping measurements, (c) produce graphic displays of alloy damping characteristics, (d) calculate damping capacities, (e) operate with commercially available hardware and software, (f) provide a programming tool for subsequent researchers to promote further development of this technique.

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I. INTRODUCTION

A. GENERAL

Audio noise reduction and vibration control of shipboard propulsion and auxiliary machinery hold obvious benefits for the Navy and are currently under investigation for application in United States Navy submarine and surface ship design. (Ref. 1: p.12) (Note 1) Conventional structural alloys generally do not exhibit significant damping capacities at stress amplitudes associated with machinery vibration and noise emission. Under prevailing conditions, as outlined by Schetky and Perkins (Ref. 2), there are three principle methods of vibration and noise control which are employed:

1. Isolation of the machinery source of vibration and noise from the surfaces to which it radiates energy.
2. Dissipation and attenuation of vibration energies generated by machinery through the use of absorbing pads (i.e., rubber insulation for pipe hangers, resilient motor mounts, etc.).
3. Attenuation of vibration and noise through the use of constituent materials whose composition and microstructure combine to absorb energy internally and dissipate it.

The first two methods are commonly employed and are effective, but they contribute significant additional weight and utilize valuable space, undesirable aspects for machinery applications aboard submarines and surface ships. The third method is less

widely applied, but has the potential to eliminate these problems, since a design may be possible without cumbersome attachments or supporting structures. However, the alloy design of high damping materials which fulfill the desired energy-absorption functions in lieu of machine parts and also satisfy the necessary corrosion properties and strength requirements of constituent materials is very difficult. (Ref 1: p. 13)

Presently, there are several problems associated with designing a material with high damping characteristics (Ref. 3: p.1).

1. Reliable and reproducible methods for accurate measurement of the energy conversion process occurring within the material are still to be developed.
2. Better understanding is required of the fundamental processes involved in the energy transfer occurring within the material (i.e., the damping mechanisms) and how these processes relate to the microstructure.
3. Preservation of damping capacities subsequent to mechanical forming is required.
4. Resistance to corrosion in a marine environment requires further investigation, particularly for the Fe-Cr alloys (Ref. 4).

Current research at the U.S. Naval Postgraduate School on materials with high internal damping mechanisms is directed toward determination of the specific damping capacities of existing commercial alloys and the relationships between the mechanisms of damping, microstructure and physical properties. Ultimately, this research should lead to the development of

alloys with optimum damping, structural forming and strength characteristics.

B. BACKGROUND

All materials display some measure of energy absorption or dissipation phenomena. However, most metallic alloys exhibit poor damping capacities at stress amplitudes associated with machinery vibration and noise emission. Specific damping capacities for common structural alloys, such as steels, brasses and aluminum alloys, are less than 1% See Table 1. (Ref. 1: p. 16). Cast materials, such as gray cast iron, typically have higher damping capacities than wrought products. The primary feature of gray cast iron which damps vibration is the large, flake-like particles of graphite in the microstructure. These large graphite flakes are effective in absorbing energy, resulting in specific damping capacities ranging from 5% to 10% (Ref. 2: p.203). Other types of cast iron, containing rounded graphite particles within the microstructure, have lower damping capacities.

TABLE 1

DAMPING CHARACTERISTICS OF SELECTED METALS AT ROOM
TEMPERATURE (REF. 2: p.16)

METAL	SDC (%)	YIELD STRENGTH (10 ³ PSI)	DENSITY (gm/cm ³)
Magnesium (wrought)	49	26	1.74
Cu-Mn alloys (INCRAMUTE, SONOSTON)	40	45	7.5
Ni-Ti alloy	40	25	6.45
Fe-Cr-Al alloy	40	40	7.4
High-C gray iron	19	25	7.7
Nickel (pure)	18	9	8.9
Iron (pure)	16	10	7.86
Martensitic stainless steel	8	85	7.7
Gray cast iron	6	25	7.8
SAP (aluminum powder)	5	20	2.55
Low-carbon steel	4	50	7.86
Ferritic stainless steel	3	45	7.75
Malleable, nodular cast irons	2	50	7.8
Medium-carbon steel	1	60	7.866
Austenitic stainless steel	1	35	7.8
1100 Aluminum	0.3	5	2.71
Aluminum alloy 2024-T4	<0.2	47	2.77
Nickel-base superalloys	<0.2	Range	8.5
Titanium alloys	<0.2	Range	4.5
Brasses, bronzes	<0.2	Range	8.5

In recent years, several new alloys have been developed which exhibit significantly higher specific damping capacities (in excess of 40%), including Cu-Mn-based alloys (SONOSTON, INCRAMUTE), Ni-Ti alloys (NITINOL), and Fe-Cr-based alloys (SILENTALLOY, VACROSIL, GENTALLOY, etc.). Damping inherent to these high damping alloys, as for any such material, originates within the microstructure. The microstructure of a material determines the mechanisms responsible for internal damping of external excitations. Some variables of the imposed vibration, such as frequency, strain amplitude and number of cycles, can of course also

influence the vibration damping response of a particular alloy. (Ref. 5) The character of the imposed excitation can produce a variety of microstructural responses, which in general result in damping due to irreversibilities incurred when a material is subjected to an alternating stress. The absorption of energy via "internal friction" is due to these irreversibilities, whether the "friction" is due to ferromagnetic domain walls or intercrystalline boundaries. The internal friction results in the energy loss per cycle which is referred to as damping. The energy losses which characterize these irreversibilities may be evident in stress-strain hysteresis, representing ferromagnetic, mechanical, and/or thermal losses. The amount of energy loss is closely tied to material microstructure as a function of:

- * the constituent elements within an alloy system
- * thermomechanical history
- * environmental temperature and whether it is above or below a "threshold" temperature
- * the imposed stress level, perhaps with respect to a critical stress level

Under cyclic (or periodic) stress, several microstructural damping mechanisms are possible, depending upon the material. Among them are:

- * dislocation damping (Refs. 5, 6)
- * interphase boundary damping (Ref. 5)
- * phase change effects (Ref. 5)

Previous research on "quiet alloys" at the U.S. Naval Postgraduate School had been concerned mainly with nonferrous alloys, specifically the Cu-Mn based alloys SONOSTON (Ref. 7) and INCRAMUTE (Ref. 8). Damping mechanisms for these alloys apparently involve the interaction of cyclic stress with twinned and "tweed" microstructures (interphase boundary damping). (Ref. 1)

In this study, as in O'Toole's (Ref. 1) and Ferguson's, (Ref. 8a), the area of interest concerns itself with iron-chromium (Fe-Cr)-based alloys, and specifically an iron-chromium-molybdenum (Fe-Cr-Mo) alloy and an iron-chromium-aluminum (Fe-Cr-Al) alloy, the compositions for which are given in Appendix A, and which were verified by two independent analysis reports. Previous research by Cochardt (Ref. 9), de Batist (Ref. 5), Schilling and Houze (Ref. 10), Willertz (Ref. 11), Suzuki, et al. (Ref. 12), Masumoto, et al. (Refs. 13-15), Schneider, et al. (Ref. 16), and Kasper (Ref. 17) has established that the damping mechanism for this alloy group results from the ferromagnetic properties of the material. According to de Batist (Ref. 5: p.43), the damping mechanism is domain boundary damping due to the magnetomechanical interaction phenomena which naturally occurs in ferromagnetic materials.

High vibration damping has been reported for several ferrous alloys, particularly for the binary systems Fe-Cr (12 - 16 wt. % Cr) (Ref. 13) and Fe-Mo (2 - 5 wt. % Mo) (Ref. 14). It has also been reported for the ternary

systems Fe-Cr-Mo (Refs. 12, 15) and Fe-Cr-Al (Refs. 18-21). A recently introduced high damping Fe-Cr-based alloy has been placed on the commercial market by Vacuumschmelze, G.M.B.H. (VAC), of Hanau, West Germany, with the registered trade name of VACROSIL-010. This material is available in two similar compositions, Fe-Cr-Al and Fe-Cr-Mo, the latter being called a corrosion resistant grade (Ref. 17). The corrosion resistant version of VACROSIL-010 (Fe-Cr-Mo) is of special interest to the Navy. For direct information regarding its corrosion resistance in seawater, reference should be made to Escue (Ref. 4).

C. OBJECTIVES

This study used a recently developed method for damping measurement; the single cantilever beam resonance dwell technique, discussed in greater detail later in this introduction. The resonant dwell technique employs forced vibration to determine the loss factor and damping coefficient of a simple cantilever beam by measuring its response to excitation at a modal frequency. (Ref. 26) This research augmented the resonant dwell measurement approach by exploring the utilization of a microcomputer to process the damping data produced by the vibrating cantilever beam.

The microcomputer currently has sufficient memory capacity to permit the processing of large programs and volumes of data. That advantage is useful to analyze the entire damping response of a vibrating cantilever beam at a resonant node. Although the assignment of Specific Damping

Capacities (SDC) and/or damping coefficients partially characterize a mechanical energy absorption material, individually those and similar numerical parameters may be insufficient to fully describe the damping response. Today, affordable equipment such as the microcomputer is available which permits broader characterization and analysis of the mechanical response of a material.

This research utilized a Zenith Z-150 microcomputer in conjunction with a Scientific Atlanta SD380Z Signal Analyzer to capture, store and analyze the dampening data produced by various specimens. Most importantly, a BASIC microcomputer program (Appendix E) was developed which accomplished the following objectives.

- * It provides a programming tool for further development of simple programs for compilation and analysis of materials damping data.
- * It provides limited automation that simplifies and facilitates the laboratory data collection and analysis process.
- * It illustrates the potential of this approach.
- * It operates with commercially available hardware and software.

For the actual vibration experiments, this research considered Fe-Cr-Al and Fe-Cr-Mo alloys of similar compositions (Appendix A) to the VACROSIL alloys with the following objectives:

- * To further determine the relationship between the room temperature damping properties of Fe-Cr-Al and Fe-Cr-Mo to applied strain (or stress) under random vibration conditions for various heat treatment histories; one hour annealing at various temperatures between 950 C and 1100 C followed by subsequent furnace cooling. This narrow region of heat treatments was

chosen because prior work (O'Toole, Ref. 1) indicated that such heat treatments produced the greatest damping capacities.

- * To produce graphic displays of alloy dampening characteristics versus sample heat treatment histories.
- * To attempt to image the ferromagnetic domains thought responsible for observed damping (Note 2).
- * To document the microcomputer analysis methods which were developed to enable further development of this technique by subsequent researchers.

D. MACROSTRUCTURAL DAMPING, MATHEMATICS & MEASUREMENT TECHNIQUES

1. Mathematics for Damping Expressions

The ability of a material to absorb vibrational energy and convert such energy to other forms, such as heat or mechanical friction, is defined as the damping capacity of the material. Specific damping capacity is the fraction of input vibrational energy or amplitude absorbed during one cycle of vibration. There are several methods to characterize the vibration damping of a material (Ref.1: p.18). Some of the more frequently employed methods are:

a. Logarithmic Decrement (δ , d)

The natural logarithm of the ratio of any two successive decaying amplitudes in time is the definition of logarithmic decrement. Free vibrations decay exponentially for a linear system. Thus, the faster the decay, the larger the decrement, indicating greater damping. (Ref. 22: p.138)
See Figure 1.

$$d = \ln(a(i)/a(i+1)) = (1/n)\ln(a(0)/a(n)) \quad (1)$$

where n = number of cycles between a(0) and a(n)

b. Quality Factor (Q)

The quality factor, often used in electronics signal analysis, is a measurement of the sharpness of a resonance peak. (Ref. 23: p.76) See Figure 2.

$$Q = \omega_n / (\omega_2 - \omega_1) = 1/2 * \text{Zeta} \quad (2)$$

where Zeta = damping factor and ω_2 & ω_1 are 3db lower than ω_n

c. Internal Friction (1/Q)

Internal friction is defined as the inverse of the quality factor. (Ref. 5: p.41)

$$1/Q = (\omega_2 - \omega_1) / \omega_n = 2 * \text{Zeta} \quad (3)$$

This expression is also known as the loss factor.

d. Normalized Bandwidth (Figure 2)

From the half power method, damping can be measured in terms of the frequency width ($\omega_2 - \omega_1$) of the peak at the resonant frequency (ω_n) at points on the curve corresponding to 0.707 (1/square root of 2) of the peak amplitude. This calculation corresponds to the points on the resonant peak at which the stored energy is half its maximum value at the resonant frequency and is normalized by that frequency. (Ref. 21: p.76)

e. Specific Damping Capacity (SDC)

SDC is the percent of strain energy dissipated during a stress cycle for a material undergoing oscillating excitation. (Ref. 24: p.444).

$$\text{SDC} = [a(i+1)^2 - a(i)^2] / a(i)^2 \quad (4)$$

If $[a(i+1) - a(i)]$ is small, SDC can be approximated by
(Ref. 24: p.444):

$$SDC = 2[a(i+1) - a(i)]/a(i) \quad (5)$$

f. Phase angle (θ)

The angle by which strain lags behind stress in cyclic or periodic loading is defined as the phase angle.

(Ref. 24: p.445)

$$\tan \theta = (1/\pi) \ln[a(i)/a(i+1)] = d/\pi \quad (6)$$

where $\pi = 3.1415927... = \text{circumference/diameter}$

For small values of damping ($\zeta < 0.5$), the following relations hold: (Ref. 8: p.18-19)

$$\tan \theta = d/\pi = 1/Q = 2\zeta$$

$$SDC(\%) = 200\pi/Q = 200 * \pi * [(w_2 - w_1)/w_n] \quad (7)$$

Specific Damping Capacity (SDC) was the parameter primarily used for damping measurements in this report.

g. Resonant Frequency ($w(n)$)

Resonant frequency is the natural frequency of a cantilever beam corresponding to the n th mode (Ref. 23: p.464):

$$w(n) = [C_n^2][E*I/m*l^4]^{1/2} \quad (8)$$

where E -- Young's Modulus of Elasticity

I -- Moment of Inertia

m -- beam mass per unit length

l -- vibrating length of beam

C_n -- function of the mode of vibration of the beam; values for several different modes (n) are given below for a clamped cantilever beam (Ref. 23: p. 466)

n	Cn	Cn ²
1	1.8751	3.5160
2	4.6941	22.0345
3	7.8548	61.6972

2. Damping Measurement Techniques

Damping measurements on Fe-Cr alloys have been performed in the past primarily using either an inverted torsion pendulum apparatus (Refs. 13-15, 19) under free decay conditions, or via forced vibration (Ref. 11). Another method which has been utilized employs the cantilever beam (Ref. 12, 16) wherein damping is also determined from the decay of free oscillations.

This study used a method that has begun to receive increasing attention, the single cantilever beam resonance dwell technique. This method, developed by Bolt, Beranek and Newman, Inc. (Ref. 25) can be used to determine the stress and frequency dependence of material damping over a 25 - 2000 Hz frequency range. The resonance dwell technique is an induced vibration method for determining the loss factor of a simple structural element by measuring its response to excitation at a modal frequency. This technique was demonstrated for vibration damping measurement by Kaufman, Kulikn, and Neshe (Ref. 26) for NiTi and CuAlNi. To summarize this approach, a cantilever beam is clamped to a bar; the bar in turn is connected at one end to an electromagnetic shaker and to a heavy base at the other. An accelerometer is mounted at the root of the sample. The input excitation signal is measured by this accelerometer.

The cantilever beam (specimen) response is measured by a second accelerometer at the free (unsupported) end of the beam. The fundamental (first modal) natural frequency "f" of a cantilever beam of length "l" (inches) and thickness "t" (inches) is: (Ref. 25: p.6)

$$f = (t/2 * \pi) * (Cn/l)^2 * (32E/Ro)^{1/2} \text{ (cycles/sec)} \quad (9)$$

where Cn is from (Eq. 8), Ro is the density of the sample in (lbs/in³) and E is the dynamic Young's Modulus. "l" is the vibrating length of the beam, while the width (an independent factor) is 0.5 inches, conforming to the width of the bar to which the specimens are clamped. See Figure 3.

The positions of the first three nodal points (n = 1,2,3) from the root of the beam, located as a fraction of the entire beam length, can be shown to be: for n = 1, l = 0.0; for n = 2, l = .53; for n = 3, l = 0.31 to 0.71.

3. Microcomputer Utilization

The practice of using two accelerometers was initially developed by Professor Y.S. Shin of the Naval Postgraduate School. In the recent work, signals produced by the input accelerometer (at the root of the specimen) and the output accelerometer (at the tip) were processed for this study by a Scientific Atlanta spectrum analyzer to produce the frequency response of the vibrating beam at a resonant mode. This method has been tested and compared to a forced torsion pendulum device for the measurement of damping in SONOSTON by Dew (Ref. 7) and further tested by

Reskusich (Ref. 8) for INCRAMUTE, and by Cronauer (Ref. 27) for Ti-Ni and Fe-Cr-Mo. Since the signal analyzer has a built-in computer interface bus and programable memory, a Zenith Z-150 microcomputer was used to operate the analyzer much of the time. Using the computer permitted: (1) storing analyzer set-up configurations, and using such set-up files to configure the analyzer much faster; (2) capturing dampening data in hard disc files and analyzing it at will; (3) combining the graphic displays relating damping characteristics of several samples on one graph; (4) writing the final report, etc.

E. MICROSTRUCTURAL DAMPING MECHANISMS OF FERROMAGNETIC ALLOYS

As discussed previously, the primary microstructural mechanisms which contribute to high damping are:

- * dislocation damping
- * interphase boundary damping
- * phase change effects

Damping in ferromagnetic materials is generally the result of two damping mechanisms. The damping caused by the magneto-mechanical hysteresis effect is the primary mode of damping. This damping mechanism is described by de Batist (Ref. 5, p.43) as a form of interphase boundary damping. A secondary mode of damping in these materials is due to the interaction of dislocations within the material (Ref. 27A). This paper is concerned with the first and primary damping mode.

Ferromagnetic materials manifest magnetic domains, which are more or less randomly oriented in an unmagnetized material. Upon the application of a magnetic field, or a unidirectional tensile (or compressive) stress, these domains tend to align with the direction of the tensile strain. Any subsequent movement of these domains produces an irreversible (but restorable) change in the dimensions of the material called "magnetostriction." When a stress-strain curve for an unmagnetized ferromagnetic material is plotted, more strain is measured than is postulated by Hooke's Law. Upon gradual removal of the load, the elastic strain reverts to zero (assuming negligible plastic deformation), but the magnetostrictive strain remains nearly constant, (i.e.), the unloading curve follows a hysteresis loop. The greater the area of the hysteresis loop, the larger the damping capacity of the material, from which it may be inferred that the damping capacities of high-strength ferromagnetic alloys are functions of magnetostriction and stress. (Ref. 1: p.26)

Considering microstructure, and summarizing, damping properties of the material are related to the movement of domain boundaries upon the application of stress. In their work with grain-oriented 3% Si-Fe, Schilling and Houze (Ref. 10) outlined their theory regarding magnetic domains as follows:

- a. Ferromagnetic domains are small magnetically ordered crystal regions within which magnetization is equal to the saturation magnetism. Therefore, the net magnetization is

a vector sum of the magnetization for all of the domains.

- b. Upon the application of a magnetic field or external stress to a magnetic material, (orientation) changes in the domain structure occur which produce changes in the overall specimen magnetization, as well as the specimen dimensions, (i.e.) "magnetostriction."
- c. Response to changes in an external field may be manifested in one of two primary manners. Either magnetization within each domain may coherently rotate to a direction parallel to the applied field, or the boundary between two domains may move; in the latter case, the changing magnetization is entirely localized at the domain boundary.

In materials such as cast 3% Si-Fe, magnetic domain misalignment is predominant; therefore, domain rearrangements occur by the movement of domain boundaries or walls between domains. These are called Bloch walls (Ref. 28: p.613) and are considered to be about 1000 angstroms thick. Bloch walls function in a manner similar to grain boundaries. They are narrow zones in which the magnetic moment vector changes from one domain to the next. Such domain boundaries have been imaged using an electron microscope by H.W. Fuller and M.E. Hale (Ref. 29), S. Amelinckx (Ref. 30), J. Silcox, E. Fuchs and others.

Stressing a ferromagnetic material acts to align the magnetic domains in the direction of the stress. Under stress (or a weak magnetic field), domains aligned with the applied field tend to grow at the expense of neighboring domains whose directions are less favorably oriented. As the applied stress (field) becomes stronger, it can also produce a rotation of the magnetic moment vector within

domains toward the direction of the applied stress (field) (Ref. 24: p.133). This domain movement results in an irreversible change in the material called magnetostriction. When energy imparted to the system in the form of mechanical vibrations produces this transformation, the resulting attenuation of applied vibrational force constitutes damping, and is in fact a relatively potent damping mechanism. (Ref. 1: p.28)

Another important point concerns the magnetic transition or Curie temperature of the material. When the temperature of a ferromagnetic material is increased, the added thermal energy reduces its degree of magnetization by permitting random domain reorientation. Heating above the Curie temperature for a short period completely transforms the material to a non-magnetic (paramagnetic) state in which the domains are randomly oriented throughout its microstructure. (Ref. 1: p.27)

Crystalline materials, whether ferromagnetic or not, exhibit effects in response to periodic stress due to dislocation damping. Under an applied stress, dislocations move in an oscillatory manner and energy is absorbed by the material. Of course, if the applied stress is high enough, the material will react plastically, and undergo an irreversible shape change.

F. MATHEMATICAL RELATIONS FOR DAMPING MECHANISMS OF FERROMAGNETIC ALLOYS

The relationship between parameters of macrostructural damping in ferromagnetic materials is provided by Cochardt (Ref. 9: p.197-199) for damping capacity, magnetostriction, critical stress, and maximum stress. The damping capacity is expressed as the logarithmic decrement (δ or "d"):

$$d = (1/2) (U_v/U) \quad (10)$$

where U = mean elastic energy of the specimen.

$$U = (1/V) * (1/2) * \int (\sigma^2/E) dV \quad (11)$$

where V is volume; σ is normal stress; and E is Young's modulus.

U_v is the energy dissipated in the entire specimen per cycle per unit volume (Ref. 9: p.197)

$$U_v = (1/V) * \int dU dV \quad (12)$$

where dU is the elemental energy loss per cycle and unit volume at the volume element dV . dU represents the area of the hysteresis loop due to the magneto-mechanical effect. For small stresses, the area of the hysteresis loop is described by: (Ref. 9: p.198)

$$dU = D * (\sigma^2) \quad (13)$$

where D is a constant according to Rayleigh's law. For stresses larger than a maximum or critical (σ_c) stress, beyond which the area of the hysteresis loop remains constant, dU is constant and can be written as: (Ref. 9: p.198)

$$dU = K * \lambda * \sigma_c \quad (14)$$

where $K = 4$ for an ideal parallelogram-shaped loop

K = 1 for most other cases
 λ = saturation magnetostriction in the
easy direction of magnetization

The assumption is made that Rayleigh's Law is valid up to this critical stress. Therefore, (Ref. 9: p.198)

$$\begin{aligned} dU &= D(\sigma^2) & 0 < \sigma < \sigma_c \\ dU &= K \lambda \sigma \sigma_c & \sigma_c < \sigma < \sigma_m \end{aligned}$$

---> $D = K \lambda / (\sigma_c)^2$ { σ_m is maximum normal stress in a cantilever beam}

Substituting the above relation into equation 12 and replacing dV by $(dV/d\sigma)d\sigma$, the logarithmic decrement becomes: (Ref. 9: p.198)

$$\begin{aligned} d &= (1/V) * (K \lambda / 2U) * \int_0^{\sigma_c} \sigma^2 / (\sigma_c)^2 * (dV/d\sigma) d\sigma \\ &+ \int_{\sigma_c}^{\sigma_m} \sigma_c (dV/d\sigma) d\sigma \end{aligned} \quad (15)$$

As previously defined, $Q^{-1} = d/\pi$.

Therefore, equation 15 can be rewritten as...

$$\begin{aligned} Q^{-1} &= (1/\pi V) * (K \lambda / 2U) * \int_0^{\sigma_c} \sigma^2 / (\sigma_c)^2 * (dV/d\sigma) d\sigma \\ &+ (1/\pi) * \int_{\sigma_c}^{\sigma_m} \sigma_c (dV/d\sigma) d\sigma \end{aligned} \quad (16)$$

It should be noted that $dV/d\sigma$ is the stress distribution function. This can be evaluated in terms of the stress conditions of a cantilever beam:

$$\sigma = M z / I \quad (17)$$

where M = bending moment
 z = distance from the neutral axis of the cantilever beam
 I = moment of inertia of beam rectangular cross section

For a cantilever beam, Cochardt continues this derivation and defines the logarithmic decrement as: (Ref. 9: p.199)

$$d = 9K \cdot \lambda \cdot E \cdot (\sigma_c / (\sigma_m)^2 * (1 - \sigma_c / \sigma_m \\ * ((3/4) \ln(\sigma_m / \sigma_c) + 15/16)) \\ \text{for } \sigma_c < \sigma_m \quad (18)$$

This equation provides an analytical expression for damping which relates several of the pertinent variables. It is apparent that after σ_c is reached, further stress tends to reduce the resultant damping, as the squared term predominates. Further, a larger elastic modulus promotes greater damping in such materials.

Damping associated with a ferromagnetic material thus reaches a maximum value at a point of critical stress. Beyond this point, gradually decreasing values of damping are recorded with increasing stress. This is attributable to a saturation condition for damping wherein the existing domains cannot grow or move any further. In addition, Degauque, Astie and Kubin (Ref. 27A) report from their experiments with high purity iron that the interaction between 90 degree magnetic domain walls and dislocation tangles appears to be a major obstruction to the motion of magnetic domain walls. Single defects like isolated dislocations can interfere with small displacements of magnetic domain walls but they can not substantially oppose the large scale movement of these walls in the vicinity of maximum damping. Therefore, an increase in dislocation density produces a decrease in the intensity of maximum damping. (Ref. 1: p.31-32)

G. METALLURGY OF THE IRON-CHROMIUM ALLOY SYSTEM

1. Physical properties of the Fe-Cr Alloys

The composition range of Fe-Cr binary alloys which are of interest as high damping ferromagnetic alloys is similar to that for ferritic stainless steels, one of the three main classes of stainless steels (the other two being austenitic and martensitic alloys). Ferritic stainless steels are iron based alloys with a chromium content ranging between 12 and 30 weight percent. The use of ferritic stainless steels has been much more restricted than austenitic stainless steels because ferritic steels are susceptible to embrittlement, are notch sensitive, and exhibit poor weldability; factors which contribute to poor fabricability. However, advantages of ferritic stainless steels include high resistance to stress-corrosion cracking, and good to excellent corrosion and oxidation resistance. Ferritic stainless steels are also known to have excellent damping properties. (Refs. 11 & 31)

Ferritic stainless steels are structurally quite simple. At room temperature, the Fe-Cr (α) solid solution has a body-centered crystal (bcc) structure. These alloys contain very little dissolved carbon, the majority of which appears in the form of finely divided chromium carbide precipitates. (Ref. 1: p.33)

The Fe-Cr binary phase diagram (Figure 4) exhibits a great deal of activity in the 11% to 12% Cr content region. As outlined by Peckner and Bernstein (Ref. 32: p.5-2 - 5-3),

the following relations and potential transformations exist.

(Ref. 1: p.33-34)

- * As a member of a group of elements described as ferritic stabilizers, chromium extends the (alpha) phase field while narrowing and suppressing the (gamma) face-centered (fcc) phase field. As evidenced in Figure 4, this creates a "gamma loop" extending in temperature range from 850 degrees Centigrade (C) to 1400 degrees C and from zero to about 12.5 weight percent chromium.
- * Whereas the transformation from alpha to gamma phase occurs in pure iron at about 910C, at an 8% concentration, chromium depresses the transition temperature to about 850C. Upon further addition of chromium, the transition temperature rapidly increases to about 1000C as the chromium content reaches 12% to 13%.
- * Whereas in pure iron the inverse transformation from gamma to alpha occurs at about 1400C, this reaction is depressed to about 1000C in the 12% to 13% Cr range. Also at this point in the phase diagram (1000C, 12% to 13% Cr), the upper and lower temperature alpha:gamma curves join to close off and form the gamma loop. Beyond 12% to 13% Cr, transformation to gamma is no longer possible and an alloy would remain ferritic (bcc) over the entire range from room temperature to melting.
- * Between the extensive alpha phase field and the gamma loop, there is a relatively narrow transition band where the alloy can have both alpha and gamma phases. Because of the narrow extent of this two phase region, depending on the annealing temperature, alloy composition and quench rate, a two phase composition may or may not be retained upon cooling to room temperature.

The defining parameters of the gamma loop have been established for the Fe-Cr binary system through the work of Baerlecken, Fisher, and Lorentz (Ref. 32: p. 5-3). Using magnetic measurements at elevated temperatures, the lowest point in the gamma loop was identified at 840C and 6.5% Cr. The greatest width of the alpha and gamma phase field occurred at 1075C and reached to about 11.5% Cr. Variations in the extent of the gamma loop were found to be very much a

function of the addition of austenizing elements, particularly carbon and nitrogen. Increasing levels of these interstitial elements causes the gamma loop to extend to higher chromium levels See Figure 5.

Another effect of carbon is that because of its low solubility in the alpha phase, excess carbon is rejected from the solid gamma solution to form complex carbides, such as $(Cr,Fe)_7 C_3$ and $(Cr,Fe)_{23} C_6$, which precipitate predominately along grain boundaries. (Ref. 1: p.35) These grain boundary precipitates are a primary factor behind the lower toughness of ferritic steels.

The strengthening mechanisms normally characteristic of stainless steels do not apply to the ferritic stainless steels. Ferritic stainless steels are characterized by the absence of an alpha \rightarrow gamma transition upon heating to high temperatures. Consequently, hardening that occurs as a result of a gamma \rightarrow martensite transformation upon cooling will not normally occur. (Ref. 1: p.36)

The greatest disadvantage to the use of ferritic stainless steels has been a loss of corrosion resistance and ductility following exposure to high temperatures. After certain heat treatments, chromium precipitates out of solution as chromium-carbides along grain boundaries, thus reducing the desirable characteristics impacted by chromium. However, the addition of molybdenum (Mo) improves the corrosion resistance of ferritic stainless steels.

Molybdenum forms benign carbide precipitates and allow Cr to remain in solution upon exposure to elevated temperatures.

2. Damping Properties of Fe-Cr Alloys

The damping properties of Fe-Cr alloys are attributable to the magneto-mechanical hysteresis mechanism associated with ferromagnetic materials. This mechanism is directly related to the physical state of the material and the associated microstructure. The following physical parameters affect the magnetic domain wall mobility of the material and subsequently its damping capacity. (Ref. 1: p.36)

a. Strain or Stress (Refs. 9,11-13,15-17,18,19,21)

The degree to which stress influences damping depends on the alloy's thermo-mechanical history. In general, damping capacity increases with applied stress or strain. Damping will reach a maximum value with stress beyond which further stress will lower damping values.

b. Cold Work (Refs. 16,17,26)

Damping capacity is strongly deteriorated by cold work. A reduction of $\geq 5\%$ completely destroys the damping effect; however, it can be fully restored by a succeeding heat treatment.

c. Magnetic Field (Refs. 9,11,14-17,20,33)

At high fields, the domain walls become fixed; i.e., the damping capacity decreases and finally disappears. Therefore, these alloys should not be used in

applications where there are stray magnetic intensity fields greater than the range of 50 - 100 A/cm.

d. Magnetic (Curie) Transformation Point
(Refs. 28, 32,34)

The magnetic transformation temperature, otherwise known as the Curie temperature, is the point above which iron is paramagnetic and, below which it is ferromagnetic. Paramagnetic iron is nonmagnetic (permeability = 1.00). Ferromagnetic iron is magnetic (permeability > 1.00), the magnitude varying with composition. At room temperature gamma-austenite (fcc) is nonmagnetic while alpha-ferrite (bcc) is ferromagnetic. Therefore, the magnetic composition and hence the ultimate damping capacity is affected by the degree of alpha-ferrite present in the structure.

Note 1: The basic format and text for this introduction were patterned after a thesis by John F. O'Toole, who conducted previous research regarding Fe-Cr vibration damping alloys (Ref. 1). However, this introduction significantly modifies and amplifies that original reference.

Note 2: Visiting Professor Yamashida conducted the electron microscope work to attempt imaging of the ferromagnetic domain walls. His assistance was graciously provided for use in this report.

II. EQUIPMENT AND EXPERIMENTAL PROCEDURES

A. PRIMARY EQUIPMENT

The user manuals noted as references 35 - 43 describe the primary equipment components used for this research, and their general configuration requirements. Figure 6 and reference 27 describe the spectral analysis instrumentation utilized, and schematics for the connection of that equipment for utilization of the resonant dwell technique. This section briefly discusses the resonant dwell apparatus, and provides installation details for the GPIB-PC computer interface board. Set-up parameters for the peripheral equipment controlled by the computer are also covered.

B. SPECTRAL ANALYSIS AND BEAM SPECIMENS

Damping measurements were performed using a modified resonant dwell technique. This method uses forced random vibrations to determine the Specific Damping Capacity (SDC) and Damping Coefficient ($\zeta = 1/(2 Q)$) of cantilever beams by measuring their response to excitation at modal frequencies. (See equations 3 and 7) (Ref. 27: p. 36) The system input and output were measured by accelerometers (Ref. 42) mounted immediately above the beam root and at the beam tip, respectively. The accelerometer outputs were compared (output/input) by a signal analyzer (Ref. 39) to produce the transfer function frequency response for the beam. Based on

this data, Specific Damping Capacity (SDC) and Damping Coefficient (DC) of the beam material was calculated. (Ref. 27: p. 36) Unlike prior research, SDC and DC were calculated by computer at the first modal frequency to demonstrate the functioning of the Signal Analyzer (S/A) Interface Program, the BASIC program developed in conjunction with this report.

The geometry of the cantilever beam specimen is defined in Figure 3. (Ref. 25) Beam width and grip length are specified, but the vibrating length (L_v) and thickness are not. Beams used in this research were originally prepared by LCDR D. Ferguson, USN, (Ref. 8a). Beam dimensions and heat treatments are provided in Table 2 below. All beams were solution treated at the listed temperatures (degrees Centigrade) and furnace cooled.

When using the technique of modal analysis, the fact that beams have multiple resonant frequencies is used to generate significant strains within the beam structure. Forced vibration at one of these resonant frequencies causes certain points (nodes) along the vibrating length to approach their maximum displacement amplitudes. The corresponding shape or response is called the "normal mode" for that resonant frequency. The first three normal modes for a cantilever beam are illustrated in Figure 7. (Refs. 23 and 27) The mode 1 (lowest) resonant frequency is known as the primary (or first) natural frequency, $W(n)$. This first

TABLE 2

Composition (Appendix 1) <u>Specimen #</u>	<u>Thickness</u> (inches)	<u>Width</u> (inches)	<u>Vibrating</u> <u>Length</u> (inches)	<u>Solution</u> <u>Treatment</u> (degrees C)
Fe-Cr-Al				
AB-1	.085	.506	7.087	1100
AB-2	.085	.513	7.071	1100
AB-4	.083	.505	7.071	1050
AB-5	.083	.506	7.087	1050
AB-7	.080	.506	7.063	1000
AB-8	.080	.506	6.909	1000
AB-10	.082	.504	6.929	950
AB-11	.083	.506	6.890	950
Fe-Cr-Mo				
MB-4	.082	.506	7.087	1050
MB-5	.082	.504	7.063	1050
MB-7	.083	.504	7.087	1000
MB-8	.083	.504	7.075	1000
MB-10	.083	.506	7.059	950
MB-11	.084	.504	7.079	950

vibration mode was employed to measure damping in this research.

A photograph of the equipment utilized for this analysis is included as Figure 8. The basic equipment configuration measured the transfer frequency response. The equipment schematic for those measurements is provided in Figure 6.

C. SIGNAL ANALYZER (S/A) & S/A ANALYSIS PROCEDURE

A Scientific Atlanta SD380Z 2-channel signal analyzer (Ref. 39) was used to generate a two volt broadband random noise signal, which was amplified at adjustable gains by a MB Dynamics 2125MB power amplifier (Ref. 41). The amplified signal was wired to drive a MB Dynamics PM-25 Vibramate

Exciter (Ref. 40). This electromagnetic shaker, which is cooled by low pressure air, provides the specimen excitation. The excitation was transmitted to the beam via a rod connected to the base of the beam clamp. The beam clamp assembly provides a 3.5 inch grip length on the beam, with the remainder of the beam free to vibrate. See Figure 3. The clamp jaws are recessed such that the excitation rod, the beam root, and the input sensing accelerometer (mounted atop the clamp) are vertically aligned. The system output accelerometer is mounted at the beam tip. (Ref. 27: p. 37 - 39)

ENDEVCO Model 2250A-10 integral electronics shear accelerometers were used to measure the transfer function (output/input excitation). These generate a voltage that is proportional to their respective acceleration amplitudes. Each accelerometer was attached via a cable to an ENDEVCO Model 4416A signal conditioner. These signal conditioners provide a constant current source of power to the accelerometers, and also amplify the accelerometer output voltage by a factor of ten. The output voltages of the signal conditioners were fed to separate channels of the signal analyzer. (Ref. 27: p. 42 - 43)

The signal analyzer was programmed to display the material transfer function response on its screen. Specifically, output voltage signals from the accelerometer

located at the beam root were fed into channel A, while signals from the one at the beam tip were led to channel C. The analyzer display depicted non-dimensional transfer function amplitude in db along the vertical axis, with frequency along the horizontal axis.

All displays S/A for first modal responses of the beams listed in Table 2 were recorded on the Zenith computer hard disc, using the Signal Analyzer (S/A) Interface Program developed for this thesis. (See the program explanation later in this report.) To assist with the computer processing of signal analyzer information, all analyzer displays that were compared as a group shared the same set-up page parameters and display screen coordinate dimensions. Further, all were produced with the MB Dynamics amplifier at the same amplification setting.

1. Signal Analyzer (S/A) Set-Up

Eleven different set-up pages are required to program the signal analyzer for operation. Regarding some of the more important parameters listed in those set-up pages, the analyzer voltage signal to the MB exciter was set at 2.0 volts; channel A input level at 0.1V, with channel C at 0.5V; 200 lines of resolution; and averaging set for a 200 target count, using the Hanning weighting function method.

As Cronauer noted (Ref. 27: p. 63), selection of an analyzer signal greater than 2.0 volts to the exciter for a broadband signal type may be prone to uncontrolled amplitude fluctuations, producing erroneous screen displays. Therefore, only 2.0 volt analyzer signals were used for this research.

The 200 target count parameter meant that the analyzer averaged 200 different data samples to establish the displays used for this report.

D. ZENITH COMPUTER

Reference 35 describes the Zenith Z-150 Computer in detail. Briefly, it is an IBM XT compatible machine, employing the Microsoft Corp. MS-DOS Version 3 (series) operating system. (IBM is the registered trademark of International Business Machines Corp.) The computer configuration was modified as the following discussion describes for the purpose of this research.

1. Hard Disc

A Seagate Corp. 30MB hard disc was installed in place of the second Zenith 5 1/4" floppy disc. The hard disc was installed according to the standard procedures given in reference 36. The hard disc was partitioned entirely under the MS-DOS format, and the computer was programmed to load the operating system from the hard disc root directory upon power-up. The S/A Interface Program, the Zenith BASICA

executive program, all analyzer data files, configuration files, etc. were located in a directory entitled "GPIB-PC".

2. Interface Board & Connections

A National Instruments General Purpose Interface Bus (GPIB-PC2A) was installed in a vacant computer utility slot.

a. The GPIB cable was led from the card, out the back of the computer, and to the bus connection on the Scientific Atlanta Signal Analyzer. The analyzer address was reset at its back panel switch station to 25. (Ref. 39, p. 8-1)

b. A second GPIB cable was "piggybacked" from the analyzer bus connection to the Hewlett-Packard Graphics Plotter. This arrangement permitted the plotter to be run by either the computer or the analyzer, though this researcher operated the plotter entirely from computer files. The plotter address was reset using its switch panel to 30. (Ref. 38, p. 9-2 & 3)

E. GPIB-PC CONFIGURATION PROGRAM

GPIB-PC software general installation procedures are covered by pages 2-3 through 2-15 of reference 37. When the operating software for the GPIB-PC is first installed, the configuration routine IBCONF must be run to enter equipment identification addresses and other operating parameters. For this research, the interface board configuration program IBCONF was filed at the root directory on the hard disc. It

is menu driven, and can be activated at the base directory by typing "IBCONF". The GPIB-PC board has the capability to service sixteen programmable instruments, as indicated by the first configuration page of IBCONF. For this report, only the the first two GPIB-PC configuration pages were enacted; DEV 1 for the Signal Analyzer, and DEV 2 for the HP-plotter. The following parameters were entered for this research:

1. GPIB-PC INTERFACE BOARD SET UP PAGE

primary GPIB address	21
timeout setting	T3S
EOS byte	00H
terminate read on EOS	yes
set EOI with EOS on write	no
comparison on EOS	7 bit
set EOI w/last byte of write	yes
GPIB-PC model	PC2A
board system control	yes
local lockout all devices	yes
disable auto serial poll	yes
high speed timing	no
interrupt jumper setting	none
base I/O address	02E1H
DMA channel	none
internal clock	5 MHz

2. GPIB-PC SET-UP PAGE for SIGNAL ANALYZER

{DEV 1 specified as S/A}

primary GPIB address	25
timeout setting	T3S
EOS byte	00H
terminate read on EOS	yes
set EOI w/EOS on write	no
comparison on EOS	7 bit
set EOI w/last byte of write	yes

3. GPIB-PC SET-UP PAGE for HP-PLOTTER

{DEV2 renamed HPPLTR}

primary GPIB address	30
secondary address	none
timeout setting	T3S

EOS byte	00H
terminate read on EOS	no
set EOI w/EOS on write	no
comparison on EOS	7 bit
set EOI w/last byte of write	no

III. SIGNAL ANALYZER INTERFACE PROGRAM

A. GENERAL DESCRIPTION

The signal analyzer interface program written for this thesis is an initial attempt to create a simple program that will: (1) set up the Scientific Atlanta Signal Analyzer; (2) capture and store graphic data compiled by the analyzer; (3) and that will conduct initial analysis of the stored analyzer data. Although this thesis was primarily concerned with computer data acquisition and processing of information associated with vibration damping alloys, most segments of the interface program can be used with any analyzer individual graphic screen display of a two dimensional (X, Y) coordinate function.

The interface program provides the additional capability of deciphering data produced by the signal analyzer into its constituent ASCII characters, and displaying such interpretation on the screen and printer. In conjunction with its data storage feature, the program's ability to interpret the stored data can assist with the composition of other programs to satisfy additional analysis needs.

B. OPERATING SYSTEM AND BASIC

The Signal Analyzer Interface Program is written in GW BASIC by Microsoft Corporation. This BASIC language is functional within the Zenith DOS operating system, supplied

as standard software with Zenith Corporation machines purchased under existing GAO contracts. Importantly, this operating-system and BASIC language are IBM-compatible, which affords additional portability for the interface utility routines. (IBM is a registered trademark of International Business Machines.)

1. BASIC Language The program was written in BASIC for several reasons. Commercial hardware and software were available for use with BASIC. Other languages such as FORTRAN, were also available, but initial evaluation suggested their use would entail additional complexity. The learning curve for this researcher was much shorter, using BASIC, a language with which he was already familiar. Also a consideration, BASIC satisfied the anticipated speed and throughput requirements.

C. INTERFACE BUS (GPIB-PC) and SOFTWARE

The Signal Analyzer interface program relies upon a National Instruments General Purpose Interface Bus designed for IBM Personal Computers and compatibles. This interface bus, or GPIB-PC for short, is a commercially available electronics card that sockets into existing expansion slots in the microcomputer. (GPIB-PC is a registered trademark of National Instruments, Austin, Texas.) This card provides the signal interface necessary for computer-to-Signal Analyzer communications. The GPIB-PC is covered in greater detail in the equipment section of this thesis.

1. GPIB-PC Software

From the programming standpoint, the GPIB-PC is supplied with software that enables direct communications using GW BASIC with programmable instruments like the Scientific Atlanta Signal Analyzer. In effect, the National Instruments GPIB-PC and its accompanying software interpret communications between the two instruments, the computer and the Signal Analyzer. To enable this facility, the GPIB-PC software does require that additional statements and functions be added to the normal BASIC program to execute the interface board communications routines.

For example, the beginning of the BASIC program <MCNFG.BAS>, lines #120 - 220 execute subroutines to operate the GPIB-PC board. Construction of these introductory program lines is provided by the GPIB-PC software. These same lines appear in several of the Signal Analyzer interface sub-programs, and must be included within any BASIC program that communicates with the Signal Analyzer.

As an example of the GPIB-PC functions added to the the BASIC language interpreter, IBWRT(variable, command) is a GPIB-PC function to write instructions to the Signal Analyzer (or other programmable instrument) via the interface board. The "variable" supplies the computer bus address for the analyzer, while the "command" supplies the operator desired instructions to be written to the analyzer.

D. HARD DISC

The system used to construct this program was composed of a Zenith Z-150 microcomputer, purchased under an existing GAO contract, and suitable for shipboard use. It is an IBM-compatible XT-type machine, with a Zenith monochrome (green) high resolution monitor. The system is described in greater detail in the equipment portion of this thesis. It is mentioned here because this system was modified to include a Seagate ST-238 Model 30MB hard disc. The interface program was intended to operate with a hard disc because the data files are large, and the hard disc operates much faster than do floppy discs.

PRIMARY PROGRAMMING FEATURES Subsequent lettered paragraphs under this heading describe some of the primary program features that are common to all the Signal Analyzer Interface Program utility sub-programs executed from the main menu.

E. MENU DRIVEN

The interface program is "Menu Driven," that is, the ten sub-programs that comprise the body of utility functions can be summoned for use from one main menu program. Once the operator has initiated the GW BASIC <TM> program environment, one merely types <RUN "MENU"> to bring the interface program menu on the screen. When activated, the Main Options Menu resides at the hub of the ten utility routines listed by the menu. Selecting a menu option, or choice, calls the selected

sub-program into computer memory and exectutes it. At the conclusion of a sub-program, the menu is redisplayed on the computer screen.

a. This structure was utilized because it was easier to write than one large program that would have attempted integration of all the utility functions together. More importantly, each sub-program was a learning experience for the writer and was used in turn to fashion the next utility sub-program. Thus, the structure evolved sequentially which accounts for its current form.

b: It is stipulated that the interface program could have been restructured, at least in part, to operate faster and more efficiently. However, the interface program is functional and due to its simple structure, the program hopefully will evolve under the scrutiny of subsequent users.

F. LINEAR DESIGN

Each utility routine follows a linear design wherein the raw data is sequentially processed by successive loops and/or sequential minor routines. If the programs are examined (Appendix E), many functional segments can be seen to be delineated by REMARK statements, most of which are labelled as to purpose, such as:

```
REM ***** No Existing File Error Trap *****
```

Frequently, remark statments describe the logic used to construct the functional routines. For example, line #1840 from the sub-program <GRDTA.BAS>:

REM The following three integers institute a "pen down" instruction.

B%(11) = 15163 : B%(12) = 17488 : B%(13) = 15163

These five digit integers comprise instructions that activate the Hewlett Packard plotter to lower its pen to paper.

Though this linear design is uneconomical from a programming standpoint, it will facilitate subsequent users in understanding the program logic and changing it as required for their purposes.

G. INTEGER VARIABLES

Two considerations underlie why integer variables and matrices were frequently employed within the BASIC programs. First, the commercial interface board used in the Zenith Z-150 computer used integer arrays to communicate data between the Signal Analyzer and the computer. Other communications algorithms are also available within the same GPIB <TM> software, but they were more difficult to utilize. Second, integer variables and arrays are more swiftly handled by the computer, which partially mitigates the linear program design.

H. ARRAYS

Throughout the interface program structure, one dimensional integer arrays are used preferentially. The arrays provided convenient "spots" or locations for the collection of data as it accumulated along the linear processing path. It is hoped that these same arrays will make

it possible for subsequent programmers to reprogram for their own needs because each array holds a particular type of data that is described within each segment's code, and by this narrative report. For instance, line #160 of the program <SCRNDTA.BAS> states:

```
REM A%(xxxxx) is a matrix used to store signal analyzer  
graphic data from the designated disc file into the computer  
active memory
```

Stored on disc directly from the interface board in the computer, this graphic data was produced by the Signal Analyzer, and is in five digit integer format, each integer representing two ASCII characters. When read from disc by <SCRNDTA.BAS>, this graphic data is stored in the matrix A%(xxxxx), each element of which is numbered from one to the end of the file.

Similar usage of matrices is employed through all ten utility programs. If a subsequent user can discern what a matrix contains, he may well be able to modify the existing program to suit his current needs.

I. ERROR TRAPS AND FILENAME EXTENSIONS

Perhaps the most difficult task connected with writing these utility routines was construction of the error trapping sections. Several traps are common to all ten routines; they are summarized as:

1. "No Existing Disc File" is a routine which captures an incorrect operator response to a program request for a disc filename, wherein the filename specified does not exist. The error trap, listed at the end of pertinent programs, provides a response "File not found; try

again." and returns the operator to the original request for a filename. Often, the incorrect response is answered with the expletive "BEEP BEEP!", which no one particularly cares to hear, but it gets one's attention.

2. IF-statements are used to capture less troublesome incorrect operator responses. For example, line #660 in the program <FPLOT.BAS> reads:

```
IF LEN(FILE$) > 12 THEN 580 : REM Limit filename length
to 12 characters.
```

As it implies, this line checks the filename response to ensure that it is 12 characters or less (an IBM DOS convention), and sends program execution back to the original request if the answer provided is greater than twelve characters long. The operator is appropriately "BEEPED" and given another chance.

To limit the required programming, and as this example illustrates, on-screen error messages are not provided for mistakes such as this. The BEEP signals a possible error, and confirmation is provided by reappearance of the incorrectly answered computer question.

3. Filename extensions are used by the program to segregate different types of files. The three types recognized are:

filename.DTA --- signal analyzer integer graphic data

filename.cfg --- signal analyzer integer machine
configurations (analyzer set-up
instructions)

filename.xyc --- integer files containing graphic X and
Y coordinates (that were decoded by
the program <DAMPCALC.BAS>)

IF-statements are used here also to test that correct filename extensions have been applied by the operator. If not, the BEEP plus second chance response is enacted by the program.

4. Undoubtedly, there are some operator responses that have not been anticipated that may "BOMB" the program. To guard against those, these instructions attempt to be detailed, and each utility sub-program called from the main menu provides banner instructions regarding that segment's intended use. Further, each computer

requested response provides short details describing the information sought from the operator. If an error does occur that causes program execution to stop and display a BASIC language error message, the routine can be immediately re-run by typing the "F2" key.

J. THE "F9" FUNCTION KEY

All ten utility programs include a program interrupt feature under the "F9" keyboard function key. Pressing the "F9" key during program operation clears the screen, and asks the operator whether he desires to continue, start the current program segment over, or exit to the main menu. If this key is pressed when the computer is requesting information from the operator, the program interrupt will not occur until after the <RETURN> key is pressed. Otherwise, the interrupt occurs immediately, and displays:

"PROGRAM INTERRUPT... "

"Type <RETURN> to resume this program section."

"Type <KK> to start this program section over."

"Type any other key + <RETURN> to exit to main menu."

"? _____ "

This feature provides some flexibility for the program operator, and permits changing menu choices even after a program segment has begun execution.

It is worthy of note that, if a disc file is being accessed when the "F9" key is pressed, that file may be left "OPEN" if the operator decides to access the main menu rather than continue execution of the current routine. Typing

"CLOSE" from the command level in BASIC will ensure that all disc files are closed on the currently selected disc.

K. SCREEN CONFIRMATION

Even when an operator input is NOT required, these programs all contain numerous screen messages to advise the operator, so that it is readily apparent the program in use is functioning correctly. For example, when a disc file is loaded by {INTDTA.BAS}, the computer echoes a portion of the loaded disc file to the screen to confirm that the contents are as expected, and that the program is indeed operating. This approach prevents the possibility of the computer "HANGING" or locking up without such a mishap being evident to the operator.

L. RESPONSES & <RETURN>

All keyboard responses requested by the S/A Interface Program require that the <RETURN> key be pressed. A null response (an empty response) is accomplished by only pressing the <RETURN> key.

IV. RESULTS AND CONCLUSIONS

A. DAMPING CAPACITY VS HEAT TREATMENT

In general, the narrow range of heat treatments produced similarly narrow ranges for specific damping capacity and damping coefficient. The Fe-Cr-Al beam samples exhibited a somewhat greater range of values, whereas the Fe-Cr-Mo beam samples were all quite closely grouped. The following table summarizes the Specific Damping Capacity (SDC) and Damping Coefficient (DC) values for the samples analyzed.

TABLE 3

Alloy	Sample Number	Heat Treatment (Degrees Cent.)	SDC (%)	DC
Fe-Cr-Al	AB-1	1100/FC	62.20	4.95E-02
	AB-2	1100/FC	40.33	3.21E-02
	AB-4	1050/FC	52.96	4.21E-02
	AB-5	1050/FC	66.83	5.32E-02
	AB-7	1000/FC	66.34	5.28E-02
	AB-8	1000/FC	50.58	4.03E-02
	AB-10	950/FC	46.87	3.73E-02
	AB-11	950/FC	42.85	3.41E-02
Fe-Cr-Mo	MB-4	1050/FC	62.95	5.01E-02
	MB-5	1050/FC	60.24	4.79E-02
	MB-7	1000/FC	51.87	4.13E-02
	MB-8	1000/FC	63.66	5.07E-02
	MB-10	950/FC	53.55	4.26E-02
	MB-11	950/FC	55.69	4.43E-02

1. Fe-Cr-Al Samples

Solution treatment of the Fe-Cr-Al samples in the 1100 to 950 degrees Centigrade range did not produce great disparity regarding damping capacity over this range. There is some slight optimization noticable in the 1000 -

1050 degree range from results for samples AB-7 and AB-5. SDC and DC noticeably decreased for both samples (AB-10 & AB-11) treated at 950 degrees Centigrade.

2. Fe-Cr-Mo Samples

The heat treatment range from 1100 to 950 degrees Centigrade produced an equally narrow range of SDC and DC values for the Fe-Cr-Mo beam samples. Similar to the Fe-Cr-Al, the Fe-Cr-Mo samples (MB-10 & MB-11) exhibited a slight reduction in SDC and DC when treated at 950 degrees Centigrade.

3. Comparison

Values calculated for SDC and DC were comparable for both alloys. The Fe-Cr-Mo appears to produce more consistent values, sample to sample, but that conclusion is probably premature, considering the small number of samples involved.

4. SDC/DC Correction Factors

Values listed in Table 3 above were generated by <GRAPHXYC.BAS>. The SDC/DC correction factors were 2.6523 for the Fe-Cr-Al samples and 2.01912 for the Fe-Cr-Mo. Samples AB-7 and MB-11, respectively, were used for the calculation of these factors. SDC values for these baseline samples calculated directly from the signal analyzer were:

AB-7	66.3442%
MB-11	55.6947%

Calculation of these factors is delineated in detail in Appendix B, specifically the program operating instructions for <DAMPCALC.BAS> and <GRAPHXYC.BAS>.

B. INTERFACE PROGRAM RESULTS Appendices C and D contain all frequency response curves and computer print-outs for the analyzed samples.

1. Appendix C: In addition to individual graphs for each beam, there are two composite graphs combining frequency response curves for samples {AB-1, AB-4, AB-7, AB-10} and {MB-4, MB-7, MB-10} respectively. The individual sample curves were produced by <CPLTR.BAS>. The composite graphs were produced from <CPLTR.BAS> and <GRDTA.BAS>.

2. Appendix D: SDC and DC computer calculated values included as program readouts in Appendix D were generated by <GRAPHXYC.BAS>. That sub-program was used vice <DAMPCALC.BAS> because it contains a curve smoothing routine that reduces inaccuracies due to "jagged" or noisy signal analyzer curves.

C. IMAGING FERROMAGNETIC DOMAINS

When this report was prepared, it was not possible to image the ferromagnetic domain walls using the transmission electron microscope at the U. S. Naval Postgraduate School. The lower lens magnetic field extended through the specimen and oriented the domain walls such that the electron beam was not sufficiently deflected to produce an image.

APPENDIX A
METALLURGICAL ANALYSIS REPORTS

LABORATORY CERTIFICATE

Anamet Laboratories, Inc.

3400 INVESTMENT BOULEVARD • HAYWARD, CALIFORNIA 94545-3811 • (415) 887-8811

APPENDIX A

Laboratory Number: 587.071
 Purchase Order: N62271-87-M-2087
 Requisition No: N62271-7117-5066
 Date Submitted: May 8, 1987
 Date Reported: May 18, 1987

Naval Postgraduate School
 Supply Officer - N62271
 Attn: Dr. J. Perkins/Georgia Gooder
 Receiving Officer Bldg. 349
 Monterey, CA 93943

----- CAPTION -----

Sample #287 was the Fe-Cr-Mo alloy. The composition was unknown by the laboratory at the time when analysis was conducted on both samples.

SUBJECT

Sample #460 was the Fe-Cr-Al alloy.

Two metal coupons were submitted for chemical analysis. The samples were identified as follows: 287 and 460.

CHEMICAL ANALYSIS
 (reported in wt. %)

		<u>Fe-Cr-Mo</u>	<u>Fe-Cr-Al</u>
Mark:		<u>287</u>	<u>460</u>
Aluminum	(Al)	0.01	2.99
Carbon	(C)	0.009	0.002
Chromium	(Cr)	11.87	11.82
Copper	(Cu)	<0.01	<0.01
Manganese	(Mn)	<0.01	<0.01
Molybdenum	(Mo)	2.93	0.01
Nickel	(Ni)	<0.01	<0.01
Phosphorus	(P)	0.007	0.007
Silicon	(Si)	<0.01	<0.01
Sulfur	(S)	0.005	0.005
Titanium	(Ti)	<0.01	<0.01
Vanadium	(V)	<0.01	<0.01

This testing was performed in accordance with the purchase order.

Submitted by;

E. A. Foreman

E. A. Foreman
 Manager, Quality Control

3c/bh51587



722 Main Street
Boylston, MA 01505
Tel. (617) 869-6401

Analytical
Report No. 0-1500

Page 1 of 4

REQUESTED BY David W. Taylor, Naval Ship R&D Center ATTENTION
Annapolis Laboratory
Annapolis, Maryland 21402

C. Wong
Code 2812
Bldg. 47, Rm. 3F

Invoice Date

10/31/86

Invoice Number	Customer's Order Number	Customer's Requisition Number	Date Received
05907	N61533-84-A-0087-V717		10/23/86
		Job order #1-2803-107-06	

DESCRIPTION

4 Samples, Stainless Steel, analyzed for elements listed
below.

RESULTS

----- CAPTION -----

SAMPLE IDENTIFICATION

Fe-Cr-Al sample analysis
for sample taken from the
edge of the ingot.

2E edge

	<u>%</u>		<u>%</u>
Carbon	.007	Nickel	.006
Nitrogen	.0011	Copper	<.001
Oxygen	.0019	Cobalt	<.001
Aluminum	2.89	Vanadium	<.001
Molybdenum	<.001	Titanium	<.001
Sulfur	.004	Iron	84.9
Chromium	11.61	Hydrogen	.0001
Manganese	<.001	Platinum	<.002
Silicon	<.002	Boron	.002
Phosphorus	<.002	Calcium	.0018

LUVAK INC.



722 Main Street
Boylston, MA 01505
Tel. (617) 869-6401

from C. Wong
Analytical
Report No. 0-1500

Page 2 of 4

REQUESTED BY David W. Taylor, Naval Ship R&D Center ATTENTION C. Wong
Annapolis Laboratory Code 2812
Annapolis, Maryland 21402 Bldg. 47, Rm. 3F

Invoice Date

10/31/86

Invoice Number	Customer's Order Number	Customer's Requisition Number	Date Received
05907	N61533-84-A-0087-V717		10/23/86
		Job order #1-2803-107-06	

DESCRIPTION

4 Samples, Stainless Steel, analyzed for elements listed below.

RESULTS

CAPTION

SAMPLE IDENTIFICATION

Fe-Cr-Mo sample analysis
for sample taken from the
center of the ingot.

3C center

	<u>g</u>		<u>g</u>
Carbon	.006	Nickel	.005
Nitrogen	.0012	Copper	<.001
Oxygen	.021	Cobalt	<.001
Aluminum	.002	Vanadium	<.001
Molybdenum	2.92	Titanium	<.001
Sulfur	.003	Iron	84.8
Chromium	11.65	Hydrogen	.0001
Manganese	<.001	Platinum	<.002
Silicon	.010	Boron	.002
Phosphorus	<.002	Calcium	.0014

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Annapolis Laboratory Code 2812
Annapolis, Maryland 21402 Bldg. 47, Rm. 3F

Invoice Date

10/31/86

Invoice Number	Customer's Order Number	Customer's Requisition Number	Date Received
05907	N61533-84-A-0087-V717		10/23/86
		Job order #1-2803-107-06	

DESCRIPTION

4 Samples, Stainless Steel, analyzed for elements listed below.

RESULTS

SAMPLE IDENTIFICATION

2C center

-----CAPTION-----
Fe-Cr-Al sample analysis
for sample taken from the
center of the ingot.

	<u>g</u>		<u>g</u>
Carbon	.007	Nickel	.010
Nitrogen	.0010	Copper	<.001
Oxygen	.0014	Cobalt	<.001
Aluminum	2.91	Vanadium	<.001
Molybdenum	<.001	Titanium	<.001
Sulfur	.005	Iron	85.0
Chromium	11.44	Hydrogen	.0001
Manganese	<.001	Platinum	<.002
Silicon	<.002	Boron	.002
Phosphorus	<.002	Calcium	.0016

7.1.1 - 713761

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By



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Analytical
Report No. 0-1500

Page 4 of 4

REQUESTED BY David W. Taylor, Naval Ship R&D Center ATTENTION C. Wong
Annapolis Laboratory Code 2812
Annapolis, Maryland 21402 Bldg. 47, Rm. 3F

Invoice Date

10/31/86

Invoice Number	Customer's Order Number	Customer's Requisition Number	Date Received
05907	N61533-84-A-0087-V717		10/23/86
Job order #1-2803-107-06			

DESCRIPTION

4 Samples, Stainless Steel, analyzed for elements listed below.

RESULTS

SAMPLE IDENTIFICATION		CAPTION	
3E edge		Sample analysis for Fe-Cr-Mo sample taken from the edge of the ingot.	
Carbon	.006	Nickel	.006
Nitrogen	.0009	Copper	<.001
Oxygen	.020	Cobalt	<.001
Aluminum	.002	Vanadium	<.001
Molybdenum	2.92	Titanium	<.001
Sulfur	.005	Iron	84.7
Chromium	11.70	Hydrogen	.0002
Manganese	<.001	Platinum	<.002
Silicon	.011	Boron	.002
Phosphorus	<.002	Calcium	.0016

LUVAK INC.

APPENDIX B

SIGNAL ANALYZER PROGRAM DESCRIPTION UTILITY SEGMENTS 1 - 10

A. MAIN MENU The Main Menu program is entitled {MENU.BAS}, and is located in the hard disc directory <GPIB-PC>. It is activated from the GW BASIC environment by typing "RUN MENU". In response to that command, the following banner menu appears:

```
*****
**                SIGNAL ANALYZER INTERFACE PROGRAM                **
**                MAIN OPTIONS MENU                                **
**                                                                **
**    <MCNFG.BAS> ..... 1                                         **
**    <FPLOT.BAS> ..... 2                                         **
**    <PRPLOT.BAS> ..... 3                                         **
**    <CPLTR.BAS> ..... 4                                         **
**    <INTDTA.BAS> ..... 5                                         **
**    <GRDTA.BAS> ..... 6                                         **
**    <SCRNDTA.BAS> ..... 7                                         **
**    <ITERPLOT.BAS> ..... 8                                       **
**    <DAMPCALC.BAS> ..... 9                                       **
**    <GRAPHXYC.BAS> ..... 10                                     **
**    EXIT THIS MENU .....ANY OTHER KEY                          **
**                                                                **
**                CHOICE? ____                                     **
**                                                                **
**                                                                **
**    PERKINS/PATCH MASTERS THESIS {NAVPGSCOL}                    **
**    COPYRIGHT AUGUST 20, 1987 UNITED STATES NAVY                **
*****
```

The blinking cursor by "CHOICE" awaits the operator's selection, an integer from one to ten, or "ANY OTHER KEY" plus RETURN>. These displayed options are the only possible responses recognized by the <MENU.BAS> program.

Each numbered choice plus <RETURN> activates a separate sub-program, all of which are explained in subsequent paragraphs. Typing any other key plus <RETURN> exits the Signal Analyzer Interface Program, but does not remove the menu from the computer memory. Thus, typing "RUN" or pressing the F2 key will redisplay the main menu.

. MACHINE CONFIGURATION {MCNFG.BAS} The machine configuration program is located under option #1 on the main menu. This BASIC program sets up the Signal Analyzer (S/A), or it stores the current Signal Analyzer configuration (set-up) on hard disc.

1. Selecting option #1 from the main menu and pressing

<RETURN> displays the following banner instruction.

```
***** Machine Configuration Program <MCNFG.BAS> *****
** This program can store signal analyzer machine configuration **
** codes obtained originally from the analyzer itself. The **
** program can also set up the signal analyzer, using any **
** configuration data files previously saved to computer disc. **
*****
** Ensure that the Signal Analyzer is connected and ON **
** and that its GPIB address is 25. **
*****
```

Type 1 to obtain & store the current configuration.

Type 2 to set up analyzer with an existing config'tn file.

1 or 2 ... ? ____

2. Signal Analyzer (S/A) requirements to use the Interface Program machine configuration routine are relatively simple.

a. The Scientific American Signal Analyzer (Model SD 380Z) operating manual provides instructions to set the machine interface buss address to 25. Selecting setup page #8 from the Signal Analyzer front control panel produces the IEEE COMMUNICATIONS setup page, the first entry of which is the Signal Analyzer address option. Note that changing this address to 25 disables the Signal Analyzer's ability to operate the Hewlett Packard graphic plotter. However, the Signal Analyzer Interface Program can operate the plotter instead.

(1) The Signal Analyzer operating manual also describes how to set switches in the back of the machine which fix its address to the chosen value each time the machine is turned on. This is a more convenient method, and the recommended method for use with the Interface Program. Setup page #8 preserves the operator's option to reset the Signal Analyzer address as required after power is applied.

3. With the Signal Analyzer turned on and its address correctly set, {MCNFG.BAS} option 1 will store the current Signal Analyzer machine configuration (all eleven set-up pages, plus screen format) to hard disc.

a. In response to an option 1 selection, the program obtains the Signal Analyzer configuration data in integer format, displays a sample of the data to the screen, confirming successful communications, and then requests...

"What file name for disc storage?"

"Note: The file designation must be cfg (ie); filename.cfg"

"Type <RETURN> to bypass disc storage?"

"Filename.cfg ... ?" ____

Filenames may be anything the operator desires, except

that the file designation must be "CFG", and filename lengths must be twelve characters or less, including the period and designation. The "CFG" extension is used by the Interface Program to keep files segregated regarding purpose, and to prevent erroneous selection of configuration files by other program segments.

Typing <RETURN> only bypasses the file storage function, and brings the following prompt to the screen:

"Type yes to run program again. " ?__

Any response beginning in "Y" (and merely "Y" itself) will redisplay the {MCNFG.BAS} banner and provide another opportunity to execute this Interface Program segment.

4. Selecting option 2 will display the Signal Analyzer configuration files previously stored to hard disc. The operator will be asked:

"What file name for retrieval from disc?"

"Note: The file designation must be cfg (ie); filename.cfg " ?__

Input of a correct filename causes the Interface Program to obtain the disc file, display a sample of its contents, then request:

"Type yes to set up signal analyzer using this file. " ?__

Again, any response beginning with "Y" will send the selected configuration data to the Signal Analyzer. Any other response will bypass the set-up function.

Following transmission of the configuration data to the Signal Analyzer, the prompt appears:

"Type KK + <RETURN> to reset using same file. "?__

This prompt permits retransmission of the same set-up parameters to the Signal Analyzer if, for some reason, the prior transmission was not received. Any response different than "KK" will bypass this option.

a. Note that if the Signal Analyzer is currently displaying a set-up page menu, it will not be apparent from the Analyzer screen that any configuration instructions were received from the computer. However, changing the Analyzer screen display to graphics will show the computer transmitted graphic set-up format, and changing back to the Analyzer set-up page will display the transmitted set-up parameters, confirming that the computer file was transmitted.

5. A response not equal to "1" or "2" will redisplay the {MCNFG.BAS} banner. However, pressing the "F9" key and <RETURN> will display mid-program exit instructions as discussed in the prior GENERAL DESCRIPTION.

6. Following completion of option "1" or "2", the operator is asked:

"Type yes to run program again. "?____

Any response beginning with "Y" will rerun the {MCNFG.BAS} sub-program. Any other response (except for F9) will exit this section and display the main menu program {MENU.BAS}.

C. FILE PLOT {FPLOT.BAS} This sub-program files Signal Analyzer (S/A) screen images as integer hard disc files that are named by the operator. Any Signal Analyzer graphic screen plot can be filed.

1. Selection of main menu option 2 produces the following computer screen display:

```
***** PROGRAM <FPLOT.BAS> *****
** This program files signal analyzer screen images in disc **
** files named by the operator. Each analyzer screen image is **
** stored as an integer array. Each element of the integer **
** array represents two ASCII code characters from the HP **
** plotter language. (Ref: HP Plotter Prog. Manual, pg. 1-8 & 9)**
** Please ensure that the signal analyzer is turned on and **
** that it's GPIB address is twenty-five (25). **
*****
** NOTE: Use <MCNFG.BAS> to store Signal Analyzer machine **
** configuration files identified as 'filename.cfg' **
*****
```

"What filename do you wish to specify?"

"Note: File designations must be dta (i.e.); filename.dta "

"Type your filename.dta " ?____

A filename response with a designation of "DTA" will cause the routine to obtain the Signal Analyzer (S/A) screen display information, display sample integer data to the computer screen, then display confirmation that the disc filename specified contains a certain number of elements and has been closed.

2. Relevant considerations are:

a. Dual Signal Analyzer screen displays may be filed, but they will not be correctly processed by the S/A Interface sub-programs {GRDTA.BAS} or {DAMPCALC.BAS}.

b. Regardless of what image or menu/set-up page is displayed on the S/A screen, this program obtains whatever is in the graphic display memory of the analyzer.

c. Each disc file of a S/A graphic screen contains about 2400 to 4600 five digit integer elements. {FPLOT.BAS} does

limit the file lengths to the minimum possible, using the integer format.

3. The Machine Configuration sub-program {MCNFG.BAS} should be used to file S/A configuration data. (See paragraph B above.)

4. PRINTER PROGRAM {PRPLOT.BAS} Selection of option #3 from the main menu executes the {PRPLOT.BAS} sub-program. This routine sends the contents of a GPIB-PC integer disc file to the printer, while displaying the same contents to the computer screen. The sub-program will print the contents of any integer disc file containing less than 10,000 elements. However, it was specifically designed to print the following file types:

- * filename.DTA ... Integer data files holding Signal Analyzer graphic screen displays
- * filename.CFG ... Integer data files holding Signal Analyzer machine configurations
- * filename.xyc ... Integer data files holding the X & Y coordinates (in HP-plotter terms) of Signal Analyzer graphic screen displays

1. Main menu option #3 causes the following instructions banner to be displayed:

```
***** Program Name <PRPLOT.BAS> *****
** This program prints the contents of a GPIB disc file on the **
** line printer. The integer disc file is printed in the same **
** format in which it was stored. Any integer disc file      **
** containing less than 10000 integer elements can be printed. **
*****
```

"Type <RETURN> to continue... " ____

Typing <RETURN> clears the screen, and displays the current existing disc files of the type described above. Further, the operator is asked:

"What filename?"

"Please include a file designation (i.e.); filename.XXX "

"where XXX is the designation."

"[----NON-INTEGGER files will not correctly load. ----]"

"Filename.xxx " ? ____

a. An incorrect filetype response {such as BASIC filename.BAS}, or EXECUTIVE (filename.EXE)} will cause the instructions banner to be redisplayed, providing the operator another chance to correctly respond.

b. A correct filetype response will load the file from hard disc and send its contents to the printer and computer screen.

2. If the operator does not desire the entire file contents, typing the "F9" function key will interrupt the routine, and display the mid-program exit options. The printer, however, may contain data in its printer buffer, so several more pages may be typed to paper unless the printer is turned off.

a. Note; turning the printer off while {PRPLOT.BAS} is operating MAY cause the program to "HANG"; that is, the computer may lock up. Turning the printer back on usually clears this condition. This condition does not occur when the "F9" function key exit option is enacted.

b. If the printer is never turned on and {PRPLOT.BAS} is executed, the program only displays file contents to the computer screen.

3. After printing the contents of a disc file, {PRPLOT.BAS} will display the prompt:

"Type yes to print another file " ?___

Any operator response beginning with "Y" will redisplay the beginning instructions banner for {PRPLOT.BAS}. Any other answer will send the operator to the main menu.

E. COMPUTER PLOTTER {CPLTR.BAS} This S/A Interface sub-program loads the contents of hard disc graphic files created by {FPLOT.BAS} and produces a hard-copy graph, using the Hewlett Packard plotter.

1. Selection of main menu option 4 displays the banner instructions:

```
***** Program Computer Plotter <CPLTR.BAS> *****
** This program uses the HP-plotter to draw a graph using data **
** from a computer disc file selected by the operator. The file **
** chosen must contain an image from the Scientific Atlanta **
** signal analyzer that was saved to disc in integer format. **
** The file designation must be {.dta}, (i.e.) filename.dta **
** Please ensure that the plotter is connected and turned on. **
*****
```

"Type <RETURN> to continue... "

Pressing the <RETURN> key clears the screen and displays:

"What file name contains your graph" ?___

Upon entry of a valid filename, the {CPLTR.BAS} routine responds:

"Loading disc file ";FILE\$;" ... Please wait... "
"+++++++ ...

"+++++ ...

When the file is loaded into the computer, the program advises:

"Plotting the disc file (filename.DTA)"

2. Upon completion of the hard-copy graph, {CPLTR.BAS} advises the number of instruction bytes written (transmitted) to the plotter, and the plotter status code, according to Table 4.1 of the National Instruments GPIB-PC Operating Manual.

3. At the conclusion of the aforementioned operations, {CPLTR.BAS} exhibits the prompt:

"Type yes to run this program again."

"Type K to print the same disc file again." ?__

a. The "K" option makes it possible to print numerous copies of the same graph before restoring the computer memory erases the graphic instructions.

b. Any input beginning with "Y" starts {CPLTR.BAS} over.

c. Any other response exits to the main menu.

4. The only preparations required for the Hewlett Packard 7470A plotter are: (1) load a pen into the left pen receptacle, (2) position the paper against the loading stop, (3) and turn on the plotter.

a. Of course, these preparations must be repeated for each new graphic image plotted. And, it is assumed that the GPIB-PC IEEE interface configuration program has been configured as described in the Equipment Section of this report.

5. INTERPRET DATA {INTDTA.BAS} This S/A Interface sub-program converts the integer contents of a GPIB-PC disc file into ASCII characters for operator interpretation. The converted code is displayed to the screen as well as printed out by the line printer.

1. Signal Analyzer (S/A) graphic screen displays, when decoded, are written in Hewlett Packard graphic plotter language. The HP-7470A Graphics Plotter Interfacing and Programming Manual contains the syntax of the HP plotter language.

2. Signal Analyzer machine configuration files, when decoded, are written in code unique to the Scientific Atlanta Signal Analyzer, Model SD380Z. The Scientific Atlanta S/A Operating Manual, Appendix contains the syntax for this code.

3. Selecting option 5 on the main menu will execute the {INTDTA.BAS} sub-program, which will display the following instructions banner:


```

*****Program Name <INTDTA.BAS> *****
** This program converts integer contents of a GPIB disc file **
** to ASCII characters for interpretation. The converted code **
** is displayed on the screen and output to the line printer. **
** (Non-integer files won't load.) {Interpretation of output: **
** Plotter language is explained in HP Plotter Prog. Manual **
** & Signal Analyzer codes in Sci. Atlanta Operating Manual.} **
*****
** NOTE: Type F9 to interrupt program printing operation if the **
** entire decoded file is not desired from the line printer. **
*****

```

"Type <RETURN> to continue... " _____

a. Pressing the <RETURN> key clears the screen and displays existing files in the disc directory, followed by the prompt:

"What filename? "

"Please include a file designation (i.e.); filename.xxx "
 " where xxx is the designation (BAS, BAT, COM or
 EXE are invalid)."

"Filename.xxx" ? _____

A correct filename will cause the loading of that file, and display of a portion of its integer contents. Then, {INTDTA.BAS} will interpret the file contents and output its results to the computer screen, as well as to the printer.

b. {INTDTA.BAS} output has the following format: (example)

```

53216 43878 21342 56564 ; ; P A 3 4 0 0
[--- GPIB INTEGERS ---] [= ASCII CODE =]

```

Four integers are followed by their respective interpretations in ASCII code, listed in the same order as the parent integers.

(1) The integer coding algorithm for this sub-program and all others in the S/A Interface Program as well is:

Integer	Integer	ASCII Characters
17488	15163	P D ; ;

where ... BB = INT(17488/256) and AA = 17488 - (BB * 256)
 P = CHR\$(AA) and D = CHR\$(BB)

DD = INT(15163/256) and CC = 15163 - (DD * 256)
 ; = CHR\$(CC) and ; = CHR\$(DD)

c. Integer file types other than filename.DTA or filename.CFG may be loaded by the program, but their interpretation

ill probably not yield any useful information, unless they were reduced by other Signal Analyzer resident software.

4. An incorrect or non-existent filename will trigger the redisplay of the {INTDTA.BAS} instructions banner, providing the operator another chance to input correct information.

5. Operation of this sub-program is similar to {PRPLOT.BAS} in that the operator may use the "F9" program interrupt key to abort its output if the entire interpreted file is not desired. As for that program, turning the printer OFF during output operations may make the computer system "HANG", that is, lock up. Turning the printer back ON usually clears this condition. If the "F9" interrupt is used, this malfunction should not occur.

6. After selected disc files are interpreted and printed, {INTDTA.BAS} displays the prompt:

"Type yes to print another file" ?_____

For all the S/A Interface sub-programs, this prompt will accept any response beginning in "Y" as an affirmative answer, and will return execution to the {INTDTA.BAS} instructions banner. At that point, the operator has an additional opportunity to interpret another disc file. Any other response will exit this sub-program and return the main menu to the screen.

7. GRAPH DATA {GRDTA.BAS} Comparison of amplitude verses frequency response for several samples can be conducted using this sub-program. {GRDTA.BAS} loads the contents of a GPIB-PC disc file; identifies the portion of that file containing just the graphic curve; then plots the curve only, using the Hewlett Packard plotter. Thus, if {CPLTR.BAS} is first used to draw the entire grid background and the first curve, {GRDTA.BAS} can add additional curves (without their respective coordinate grids) for direct comparison. Of course, all curves displayed together must have originated from S/A screen displays with common coordinate grids.

1. Main menu option 6 will call the following {GRDTA.BAS} instructions banner to the computer screen:

```
***** Program <GRDTA.BAS> *****
* This program loads the contents of a designated GPIB disc file **
* containing integer data into the computer; identifies the file **
* graphic data section, then plots that disc file graphic data **
* using the Hewlett Packard plotter. This program can be used **
* to plot several signal analyzer graphic displays on the same **
* page, providing direct comparison of different sample results. **
*****
* NOTE: Curves plotted together on the same plotter display **
* should all have originated from equivalent coordinate scales **
* when they initially were displayed on the Signal Analyzer. **
*****
```


"Type <RETURN> to continue... " ?___

Pressing the <RETURN> key will clear the screen, display the current graphic data files, and request:

"What file name contains your data?"

"File designation must be dta (ie); filename.dta "

"Note: File design's <EXE>, <BAS>, <BAT> & <COM> will not load."

"Filename.dta ..." ?___

2. Entering a valid filename will start the {GRDTA.BAS} sub-program execution. As the program operates, it will exhibit screen messages describing its operational stages. At the point where the selected graph is plotted, the routine displays the screen message:

"Plotting the selected graphic data ... "

"Calling IBWRTI(B%(matrix))... "

"The interface board function to plot the data... "

This message refers to the GPIB-PC computer interface board and its software function IBWRTI() that outputs the graphic data (stored in B%(matrix)) to the HP-plotter.

3. At the conclusion of the plotting operation, the routine {GRDTA.BAS} displays the location within the selected file of the graphic information. The index numbers of the integers containing the start and end of the graphic curve are shown on the computer screen by the prompt:

"Starting integer # = " (start index) "Ending integer # = " (ending index)

The numbers provided begin with the first integer of the disc file.

4. The following prompt is also displayed at this time:

"Type <KK> to RE-PLOT the same graph."

"(Reposition graph paper to origin for a re-plot.)"

"Type yes to run the program again..." ?___

a. As it indicates, a response of <KK> will replot the same graphic information. Reposition the paper to its top edge and the pen to the left side of the plotter (HP Plotter Op. Manual, position P1) before this operation occurs or an unwanted line will result when the pen is drawn backwards across the page.

b. An entry of <YES> or any entry starting with "Y" will restart {GRDTA.BAS} by clearing the screen and displaying the starting instructions banner.

c. Any other entry will exit this sub-program and return the operator to the main menu.

. SCREEN DATA {SCRNDDTA.BAS} This program interprets and displays the contents of an integer GPIB-PC disc file on the computer screen. It provides the additional facility of being able to select at will the portions desired for interpretation and display. The operator can move about within the data file contents as necessary to examine whatever portion is required. Since the entire disc file is loaded into computer RAM, the routine is fairly rapid once the disc file has been loaded.

1. Selecting main menu option 7 activates the {SCRNDDTA.BAS} sub-program. The following instructions banner is shown on the computer screen:

```
***** Program to display disc file <SCRNDDTA.BAS> *****
** This program loads the contents of a designated GPIB disc file **
** containing integer data into the computer and then displays    **
** the contents and its decoded ASCII characters for analysis.    **
** Note: File design's can not be <BAT>, <BAS>, <EXE> or <COM>.    **
*****
```

"Type <RETURN> to continue... " ? ____

1. Typing <RETURN> clears the screen and exhibits the prompt:

"What file name contains your data" ? ____

correct filename entry will cause the designated file to be loaded into computer memory. An incorrect or non-existent filename will trigger redisplay of the instructions banner.

2. When the disc file is successfully input to the computer, the prompt occurs:

"Disc file " <filename> "is loaded into active memory ..."

"Designate the number of the starting byte... " ? ____

mindful that integer disc files containing graphic data are approximately 3600 - 8200 integer elements long, enter the integer index number of the desired starting point. The program will request the number again if an incorrect value outside the file boundaries is attempted. If a character value is entered, the BASIC operating system requests re-entry.

3. After selection of the starting integer value, the next prompt is:

"Designate the number of the ending byte... " ? ____

The same type of conditions apply here as for the starting index

number. {SCRNDTA.BAS} will request the entry again if the stipulated integer number is outside the file boundaries, and also if the number chosen is negative or less than the chosen starting index.

4. With the starting and ending indexes chosen, {SCRNDTA.BAS} locates the designated information, interprets it, and prints to the screen:

"Your chosen data bytes contain... "

"Byte #	Byte #	Integer	Integer	ASCII Characters "
1	2	17235	11313	S C 1 ,
3	4	12345	12336	9 0 0 0
5	6	12588	12844	, 1 , 2.
7	8	13621	17467	5 5 ; D
9 ... (etc.)				

The numbers displayed here are examples of how the interpreted results appear. The computer screen fills with nineteen lines of information, then requests that <RETURN> be pressed to continue with the next screen. This method permits the operator to step through the displayed information at a readable pace.

a. If the "F9" interrupt key is pressed, the operator may choose to continue with the current file; examine another disc file; or exit to the main menu.

5. When all chosen information has been interpreted to the screen, the following prompt appears:

"Type yes to look at other data bytes... " ?___

At this point, other sections of the file held in computer memory may be examined. This feature permits the operator the flexibility to move about within the chosen file.

6. Entry of <RETURN> or any key plus <RETURN> activates the prompt:

"Graphic file contained " <number> " total bytes of data."

"Type yes to examine another disc file... " ?___

An affirmative reply will re-exhibit the {SCRNDTA.BAS} instructions banner, at which time the operator may press <RETURN> and select another file for examination. Any other response not starting with "Y" will return execution to the main menu.

7. During operation of the {SCRNDTA.BAS} routine, when a hard copy is desired of information shown on the screen, the <PrtSc> key

an be used to send it to the printer. Also, <Ctrl><PrtSc> will send all screened information to the printer, if desired. Typing <Ctrl><PrtSc> again releases this selection.

. ITERATIVE PLOT {ITERPLOT.BAS} With this S/A Interface sub-program, any chosen portion of an integer graphic file may be drawn with the HP-plotter. {ITERPLOT.BAS} loads the disc file, requests identification of desired sections from the operator, then plots the chosen information. During development of the Signal Analyzer Interface Program, this routine was used to gain necessary insight into the construction of graphic data from the analyzer.

1. Operation of {ITERPLOT.BAS} is very similar to {SCRNDTA.BAS}. Information requested from the operator, and the program screen prompts requesting that information are similar. Therefore, explanations listed in this section are appropriately abbreviated where clarity is not compromised.

2. Choosing entry 8 from the main menu brings the following instructions banner to the screen:

```
***** Program <ITERPLOT.BAS> *****
** Program to selectively plot data from an operator design'd **
** disc file. This program runs the HP-plotter to draw a      **
** graph using designated portions of graphic data from a      **
** disc file that was originally obtained from the Scientific **
** Atlanta signal analyzer screen display by <FPlot.BAS>.      **
*****
```

"Type <RETURN> to continue... " ? ____

the <RETURN> key causes display of the request:

"What disc file do you wish to plot? "

"Note: File designation must be dta (i.e.) filename.dta "

"What filename.dta " ? ____

3. Subsequent to selection of the disc file and its input to the computer, the following message appears:

"Note: The first several data bytes from the disc file contain graphic scale and pen positioning instructions. Thus, you need at least the first ten bytes to produce a readable graphic segment on the HP plotter."

"Designate the number of bytes you wish to use from the beginning of the disc file {scale, border, etc.} "

? : ____

the above instructions imply, the first eight to twelve elements of the integer graphic data file contain scaling and plotter pen positioning instructions. This screen input requests the operator to

designate how many of the initial file elements he wishes to use. A zero or null input is accepted; however, the subsequent plotter image may not be discernable without the omitted scaling instructions.

a. Negative values and those greater than the original file length will be rejected, and the above prompt redisplayed.

4. The next screen message is:

"Designate the starting byte for the graphic data... " ?___

Followed by:

"Designate the ending byte for the graphic data... " ?___

Upon completion of these messages, the computer program advises:

"Plotting the rearranged data... " .

At this time, the selected file sections are drawn by the HP-plotter. Since key elements of the plotter instructions may have been omitted by the operator's choices, the plotter image may be confused. The utility, however, of this program is that it provides graphic illustration of the composition of graphic files produced by the Signal Analyzer.

5. When the plotter completes its operations, the computer screen states:

"plotter status... " (number)

"Type K + <RETURN> to plot the same graph. "

"Type I + <RETURN> to select and plot different portions
of the same graph. "

"Type <YES> + <RETURN> to select another disc file."

"Type <RETURN> to exit to main menu. " ?___

a. Plotter status is a GPIB-PC interface board code, listed in Table 4.1 of the National Instruments GPIB-PC Operating Manual. It is useful as a programming tool.

b. The remaining screen messages provide the opportunities to re-plot the same information; select different portions of the same file, now resident in the computer memory; select another disc file for {ITERPLOT.BAS} to process; or to exit to the main menu.

J. DAMPING CALCULATION {DAMPCALC.BAS} This sub-program is the longest and longest running of the Signal Analyzer (S/A) Interface Program routines. It combines many of the features from previously discussed sub-programs. It also deciphers the X and Y coordinates from within

ny Signal Analyzer single graphic image file. From those coordinates, {DAMPCALC.BAS} also calculates the Specific Damping Capacity (SDC) and Damping Coefficient (DC).

1. The computer calculated values for SDC and DC are relevant for nodal frequency curves of amplitude verses frequency.

2. <DAMPCALC.BAS.> will correctly decipher and store the integer and Y coordinates from any single S/A curve. However, it was designed for amplitude verses frequency curves with a single maximum, so its SDC and DC calculations will not produce meaningful results for other curve shapes. The sub-program should, nevertheless, operate without program fault on other curve shapes.

3. Since the analyzer produces somewhat "jagged" curve shapes, depending on its configuration and the material tested, SDC and DC results from <DAMPCALC.BAS> may be influenced by such irregularities. <GRAPHXYC.BAS> employs a curve smoothing routine to reduce the effect of such jagged curves.

4. The deciphered X and Y coordinates are in terms of the Hewlett-Packard graphic plotter scale. With sufficient knowledge of the original graph, these coordinates can be interpreted to other coordinate scales. In any event, the coordinates produced by <DAMPCALC.BAS> accurately represent the original Signal Analyzer display, the curve portion of which can be reproduced on the computer by <GRAPHXYC.BAS> (Main Menu selection 10).

5. Main menu selection 9 calls the following banner to the computer screen:

```
***** Program <DAMPCALC.BAS> *****
* This program loads the integer contents of a designated GPIB **
* disc file into the computer; identifies the file graphic data **
* section; then calculates the Specific Damping Capacity (SDC) **
* and the Damping Coefficient (DC) for the selected data file. **
* SDC & DC are calculated in absolute HP-plotter coord terms **
* and may vary some from Signal Analyzer values. This program **
* will also store the S/A graphic XY-coordinates as absolute **
* HP-plotter integer magnitudes, if desired. {The program **
* <GRAPHXYC.BAS> can display stored disc file graphic data on **
* the microcomputer screen. (Selection #10 from the Main Menu)} **
*****
* Note: This program will not function correctly with signal **
* analyzer dual screen traces that are stored to disc. GPIB **
* disc data files must be single traces of amplitude vs freq. **
*****
```

"Type <RETURN> to continue... " ?__

6. The <RETURN> key clears the computer screen, then triggers

the display of all graphic data files currently existing on the hard disc. The file directory information is followed by:

"What file name contains your data?"

"File designation must be dta (ie); filename.dta "

"Filename.dta ..." ?__

A correct filename input starts {DAMPCALC.BAS} execution which is confirmed by the screen prompt:

"Loading the contents of " (filename) "into the computer..."

"Disc file contents are ... Please wait... "

7. While it loads the file, the computer echoes the file contents to the screen. This exhibition of {DAMPCALC.BAS} program execution is also practiced for subsequent program sections. Screen messages appear that are descriptive of the program operations being executed. The operator may use the <Ctrl>(NumLck) keys to temporarily stop the screen displays for examination. Program execution starts again with any key pressed.

8. The next screen message requesting operator information is:

"Graphic XY-coordinates for ";FILE\$;" have been determined. "

"Type <YES> to store XY-coordinates... " ?__

a. Any entry not beginning in "Y" bypasses this option.

b. An affirmative response produces the message:

"What XY-coord filename?"

"File designations must be XYC (ie) FILENAME.XYC "

"Filename.XYC ... " ?__

The operator may enter any filename of less than twelve total characters in length, as long as the designation is "XYC". The S/A Interface program utilizes the "XYC" extension to similarly label all XY coordinate files, making their directory identification much easier. Responding to a valid filename, the program answers:

"Storing your XY-graphic coordinates... "

9. Subsequently, {DAMPCALC.BAS} lists the X and Y coordinates of the selected file to the screen, then requests:

"What SDC/DC correction factor" ?__

During the development of the S/A Interface Program, this researcher chose to write a manual correction factor into the {DAMPCALC.BAS}

routine. This factor corrects for X and Y coordinates being produced by the analyzer and determined by the program in HP-plotter scale values. The factor need be determined only once for each group of disc files originating from common analyzer screen grids.

a. The method to determine the SDC/DC correction factor is accomplished by:

* Use the formulas ... $SDC = 200 \text{ PI } (W(2) - W(1))/W(n)$

$DC = (W(2) - W(1))/(2 W(n))$

where ... $PI = 3.1415927$

$W(1)$ & $W(2)$ are the frequency values at the half-power points on either side of the resonant frequency

$W(n)$ is the nodal resonant frequency

* Manually calculate SDC (or DC) from a Signal Analyzer display that has the same coordinate scale as the group of graphic files in question.

* Process the same Signal Analyzer graph used for the SDC (or DC) manual calculation with {DAMPCALC.BAS}, entering an initial SDC/DC correction factor of one (1); (i.e.) no correction, in response to the program request for a factor.

* Divide the manually derived SDC (or DC) value into the {DAMPCALC.BAS} generated SDC produced with no correction. The numerical result of this division is the SDC/DC correction factor, applicable to all graphic files that were produced from common S/A displays. Note that for this factor to be trully common for all files in a group, S/A output voltages, and similar critical configuration set-up page parameters must also be shared.

b. The program algorithm for calculation of SDC and DC depends upon determination of the curve baseline so that half-power points can be found as (1/square root of 2) times the maximum amplitude. The curve baseline is found by averaging the Y coordinate values at the left and right ends of the curve in question. HP-plotter coordinate values assigned by the S/A are not zero at the curve minimums, but have magnitudes that must be included when calculating SDC and DC. See <DAMPCALC.BAS> program lines 3880 - 3900 and <GRAPHXYC.BAS> program lines 2200 - 2300.

10. Entering a valid SDC/DC correction factor produces the following screen report:

```
*****
"  VALUES FOR " (filename)  "YMAX(Abs) = " (Ymax coord)
"  SDC = " (SDC) " % "      "X(0) = " (X minimum)
"  DC  = " (DC)             "XMAX(Abs) = " (X maximum)
"-----"
"  SDC/DC CORRECTION FACTOR OF " (correction factor)
*****
"Type any key + <RETURN> to ReEnter the SDC/DC factor "
```

The listed YMAX(Abs) value is the maximum vertical graphic coordinate, or the maximum amplitude in HP-plotter scale terms of the curve in question. X(0) is the minimum horizontal graphic coordinate, while XMAX(Abs) is the maximum value in HP-plotter scale terms for the {DAMPCALC.BAS} processed curve.

11. In the same fashion as prior discussed sub-programs, this routine has a final screen message which enables {DAMPCALC.BAS} to be rerun for a different disc file.

```
"Type yes to examine another disc file... " ?___
```

Any response not starting with "Y" returns the main menu to the computer screen.

K. GRAPH XY COORDINATES {GRAPHXYC.BAS} The last main menu selection in the S/A Interface Program is a routine that graphically displays the curves stored to disc as X and Y coordinates by {DAMPCALC.BAS}, the previous menu selection. {GRAPHXYC.BAS} reads the files with ".XYC" extensions from the hard disc; finds the maximum amplitude coordinate pair; "smoothes" the curve coordinates and finds the half-power points; calculates the Specific Damping Capacity (SDC) and Damping Coefficient; and then displays the selected graph on the computer screen with the half-power points marked. The original curve and its "smoothed" version are both displayed to provide verification that the processed graph is a close approximation of the original.

1. Main menu selection 10 executes {GRAPHXYC.BAS} which begins with the banner instructions:

```

***** Program <GRAPHXYC.BAS> *****
** This program loads the XY-coordinate contents of a designated **
** disc file into the computer, then displays those coordinates **
** graphically on the computer screen. A second curve is also **
** displayed that is a SMOOTHED version of the disc file graph. **
** The SMOOTHED version is used for SDC & DC calculations, so **
** its visual FIT to the disc file graphic data is displayed on **
** the computer screen for comparison. XY-coord disc files used **
** by this program must have been produced by <DAMPCALC.BAS>. **
*****
** Note: Disc files for this program must have file designations **
** of <XYC> (ie) FILENAME.XYC Other file types will not **
** load correctly. **
*****

```

"Type <RETURN> to continue... " ?__

2. Typing the <RETURN> key clears the screen, displays the directory of XY-coordinate files, and exhibits the program request for a filename:

"What file name contains your XY-coord data?"

"File designation must be xyc (ie); filename.xyc "

"Filename.xyc ..." ?__

Only XY-coordinate files generated by {DAMPCALC.BAS}, or files that have the X and Y coordinates stored as integers in the sequence "X1 Y1 X2 Y2 X3 Y3 X4 Y4 etc. ..." will load correctly. Upon the entry of a valid filename, the routine advises:

"Loading the contents of " (filename) " into the computer... "

"Disc file contents are ... Please wait... "

023	19	1087	21	1151	21	1215	18	1279	20	1343	21
404	20	1471	21	1535	22	1599	24	1663	26	1727	27
855	27	1919	29	1983	30	2047	30	2111	31	2175	32
239	32	2303	33	2367	35	2431	38	2559	38	2623	40
687	41	2751	42	2815	44	2943	44	3007	46	3071	46
135	48	3199	50	3263	50	3327	52	3391	53	3455	56
519	58	3583	61	3647	61	3711	63	3775	63	3839	64
903	65	3967	70	4031	71	4095	71	4159	74	4223	75
287	78	4351	82	4415	85	4479	83	4543	84	4607	90
671	92	4735	91	4799	92	4863	94	4927	95	4991	97
055	103	5119	103	5183	99	5247	99	5311	94	5375	93

....etc.

imilar to prior programs, the disc file contents are exhibited on the screen for verification of correct operation. Note that, depending on the coordinate values, file contents may not line up in neat columns as the above example implies.

3. {GRAPHXYC.BAS} also calculates SDC and DC for the chosen graph. The calculation also depends on the entry of an SDC/DC correc-

tion factor entered by the operator, just as it did in {DAMPCALC.BAS}. The procedure to calculate the correction factor is exactly the same as that explained in paragraph J above. Therefore, it is not reiterated here.

a. After entry of the SDC/DC correction factor, the results appear as:

```
"*****"
```

```
"RESULTS FOR " (filename)
```

```
"SDC = " (SDC) " Percent "
```

```
"DC = " (DC)
```

```
"PLOTTER COORD YMAX(Abs) = " (Y maximum)
```

```
"X(0) = " (X minimum) "X(MAX) = " (X maximum)
```

```
"SDC/DC CORRECTION FACTOR IS " (factor)
```

```
"*****"
```

```
"Type any key + <RETURN> to ReEnter the SDC/DC factor " ?____
```

4. Pressing the <RETURN> key only (entering a null response) will advance program execution to the prompt:

```
"Type <RETURN> for graph of file data." ?____
```

Typing the <RETURN> key once again will clear the screen and graph the curve on the computer monitor. The graph is displayed with a ten-by-ten grid across the screen. In the upper left corner of the graphic display, the message appears:

```
"SCREEN TRACE OF " (filename) " SIGNAL ANALYZER DISC FILE"
```

```
"A positive XFCTR moves trace to the right. A positive YFCTR moves "
```

```
"screen trace down. <XFCTR + YFCTR = 0> exits the graph mode ... "
```

```
"WHAT XFCTR = " ?____
```

```
"WHAT YFCTR = " ?____
```

a. The computer monitor graphic origin is at the upper left of the monitor screen. Thus, monitor X-coordinates increase in value from left to right, the usual convention. But, Y-coordinates increase in value on the monitor from top to bottom, the reverse of the common convention.

b. To move the graphic curve LEFT and DOWN, enter a negative integer for "XFCTR" and a positive integer for "YFCTR". Integer multiples of twenty (20) to thirty (30) provide reasonable motion in the desired directions.

5. The graphic display section of {GRAPHXYC.BAS} can be exited with two successive null entries [<RETURN> and <RETURN>], or any two values XFCTR + YFCTR which sum to zero. That combination produces the final screen message:

"Type yes to examine another disc file... " ?____

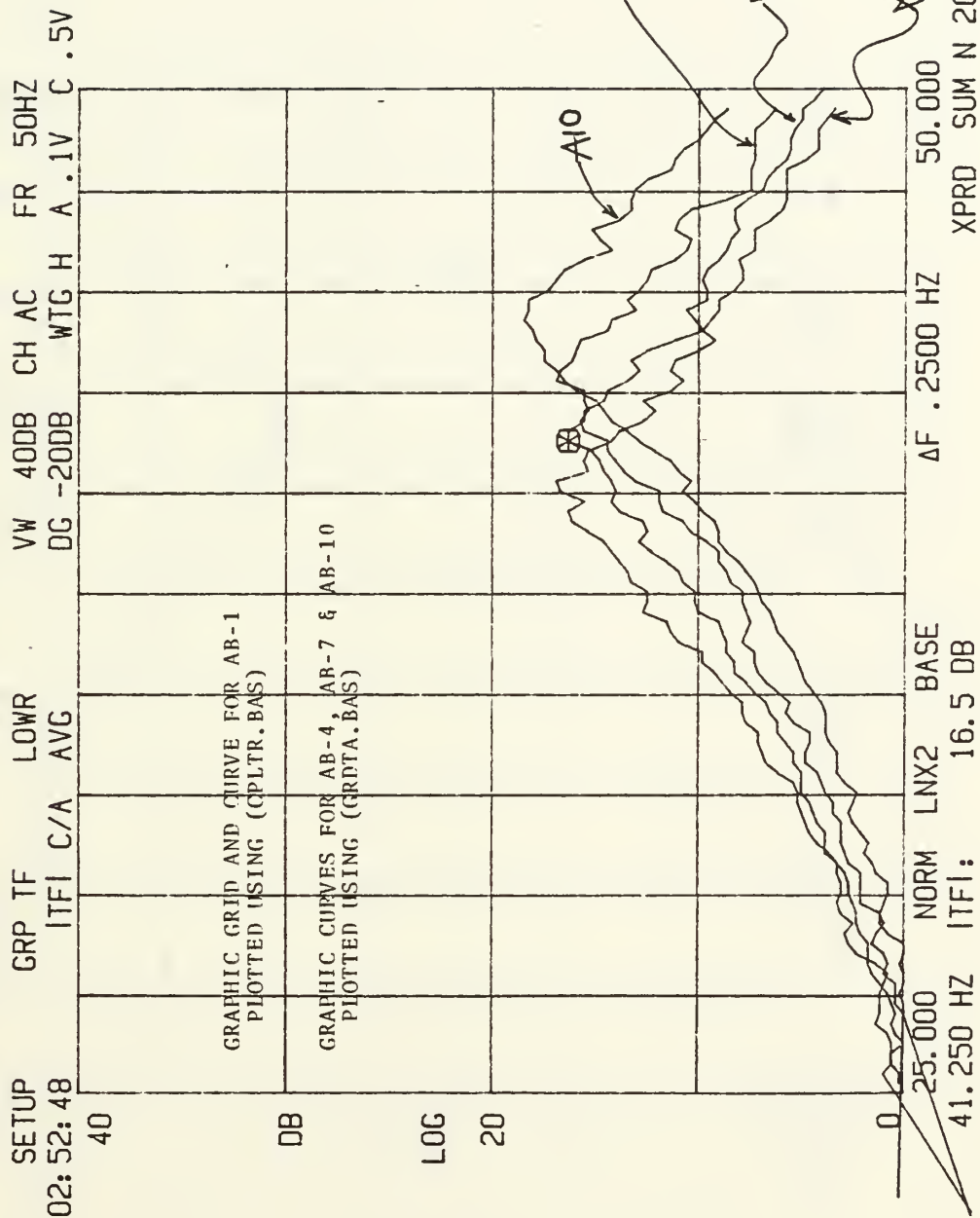
A negative answer (not beginning with "Y") returns the operator to the main menu.

6. The curve smoothing routine used in <GRAPHXY.BAS> is listed in program lines 1420 - 2180. The smoothing routine operates on the Y-coordinate values only; X-coordinate values and indecis remain unchanged. The routine calculates an average Y-coordinate increment for the left half of the maxima curve (LYI). Similarly, an average Y-coordinate increment is figured for the curve portion to the right of its maximum (RYI). These average increments are proportionally summed in program lines 1980 and 2140 to approximate the left and right halves of the original curve with more continuous versions. Factors of .05 and 1.2 appearing in these program lines can be changed by the programmer to vary the shape of the "smoothed" curves produced. These factor values worked well for modal maximums displayed over a 25 Hz frequency range.

APPENDIX C

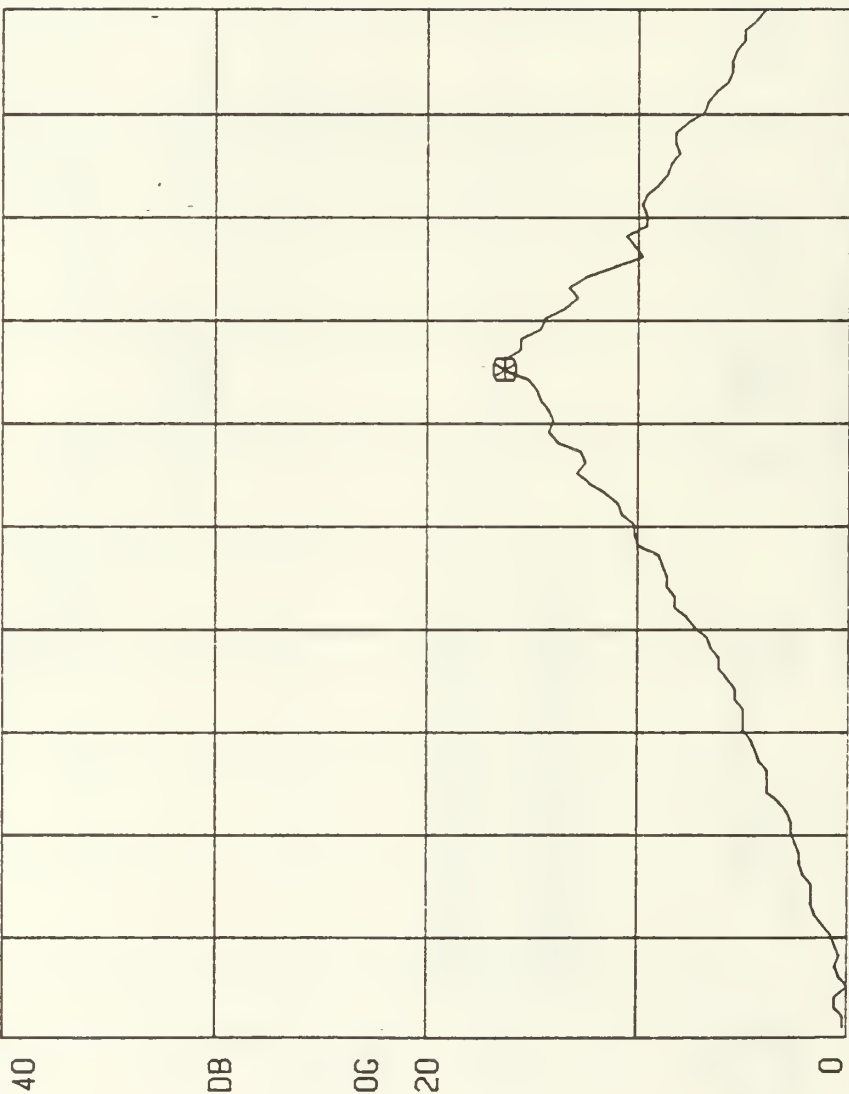
GRAPHIC PROGRAM OUTPUT/RESULTS

COINCIDENT GRAPHIC PLOTS FOR SAMPLES
AB-1, AB-4, AB-7 & AB-10



AB-1 1100 Peg C & FC

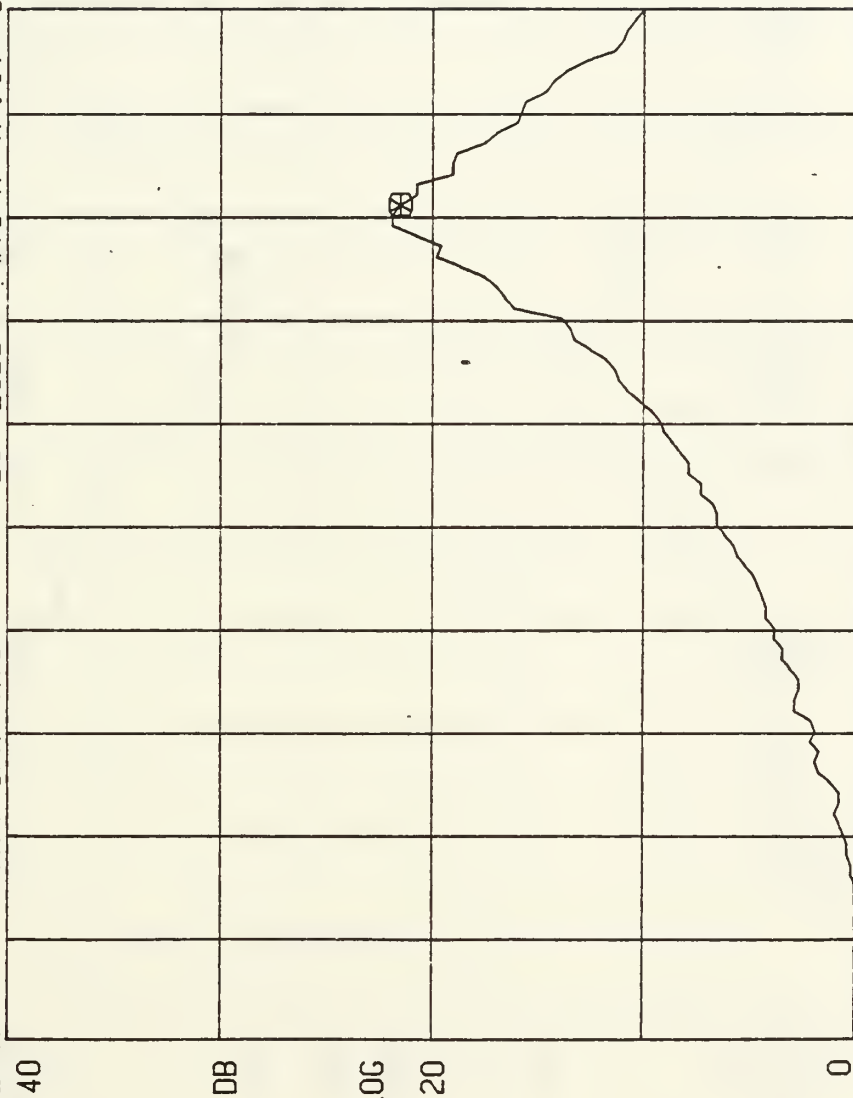
SETUP 02:52:48
GRP TF ITFI C/A LOWR VW 400B CH AC FR 50HZ
ITFI C/A AVG DG -200B WTG H A .1V C .5V



NORM LNX2 BASE
ITFI: 16.5 DB
XPRD SUM N 200

AB-2 1100 Deg C & FC

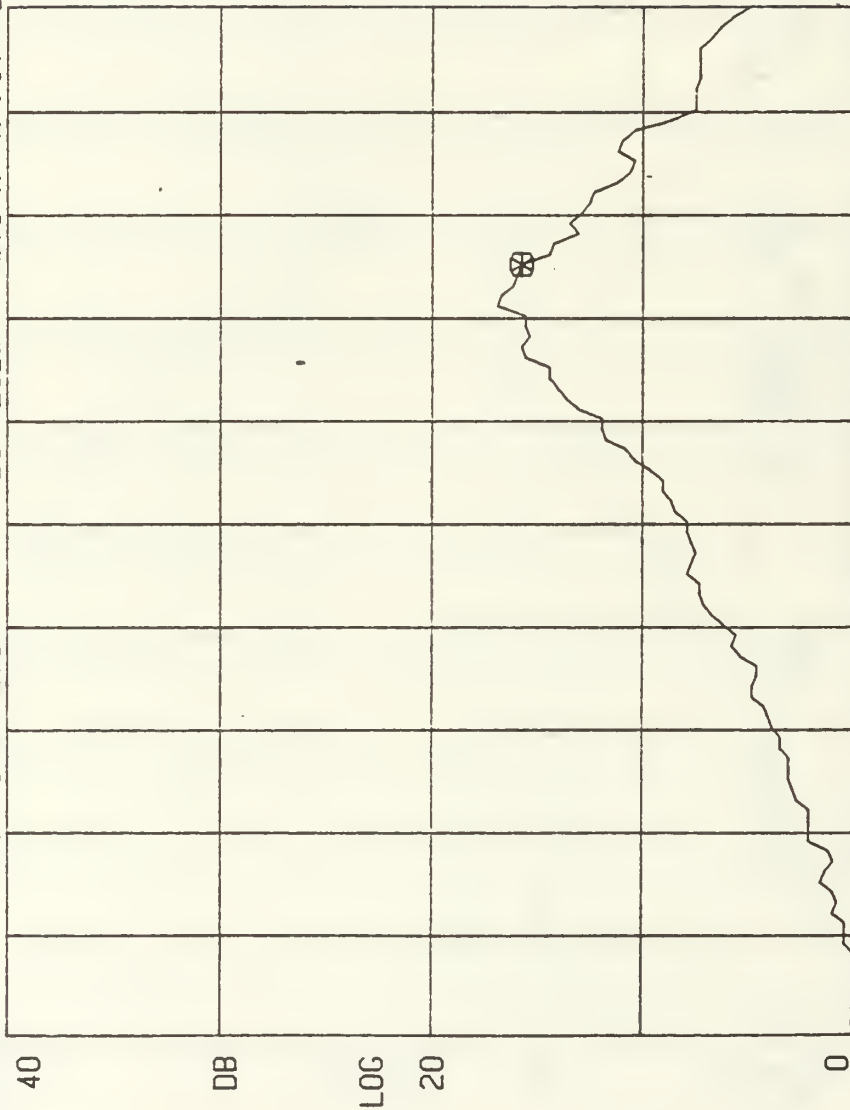
SETUP 03:12:48 GRP TF ITFI C/A LOWR VW 40DB CH AC FR 50HZ
03:12:48 ITFI C/A AVG DG -20DB WTC H A .1V C .5V



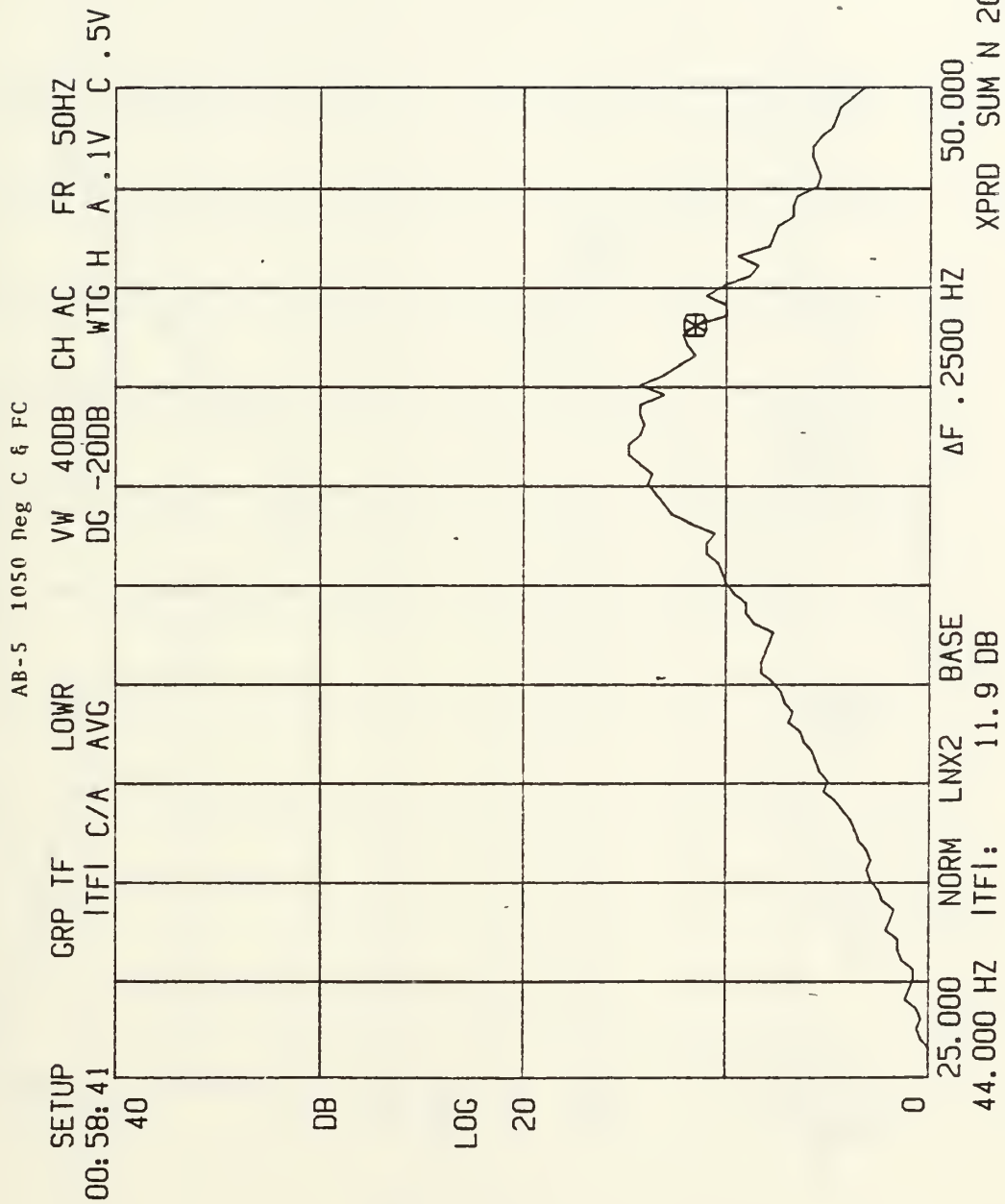
25.000 NORM LNX2 BASE 45.250 HZ ITFI: 21.8 DB
45.250 HZ ITFI: 21.8 DB
50.000 XPRD SUM N 200

AB-4 1050 Deg C & FC

SETUP 00:40:45
 GRP TF ITFI C/A
 LOWR VW 40DB CH AC FR 50HZ
 DG -20DB WTC H A .1V C .5V

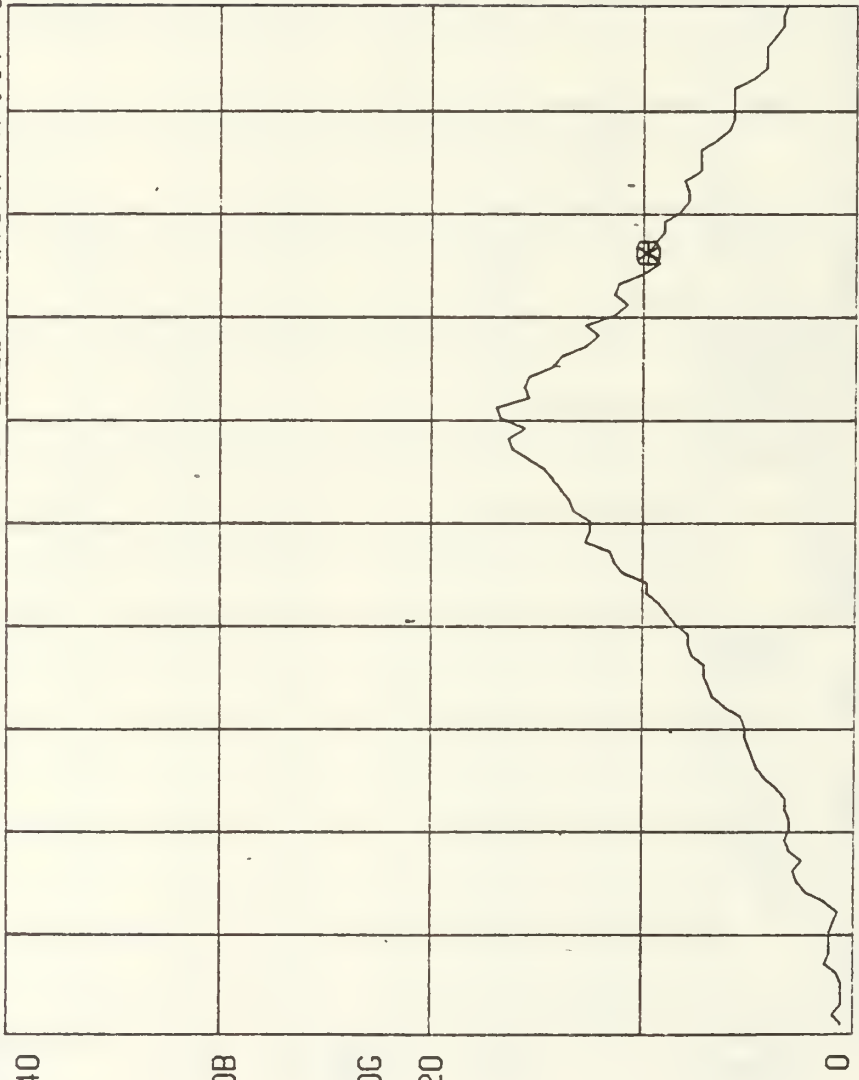


25.000 NORM LNX2 BASE
 43.750 HZ ITFI: 15.9 DB
 50.000 XPRD SUM N 200



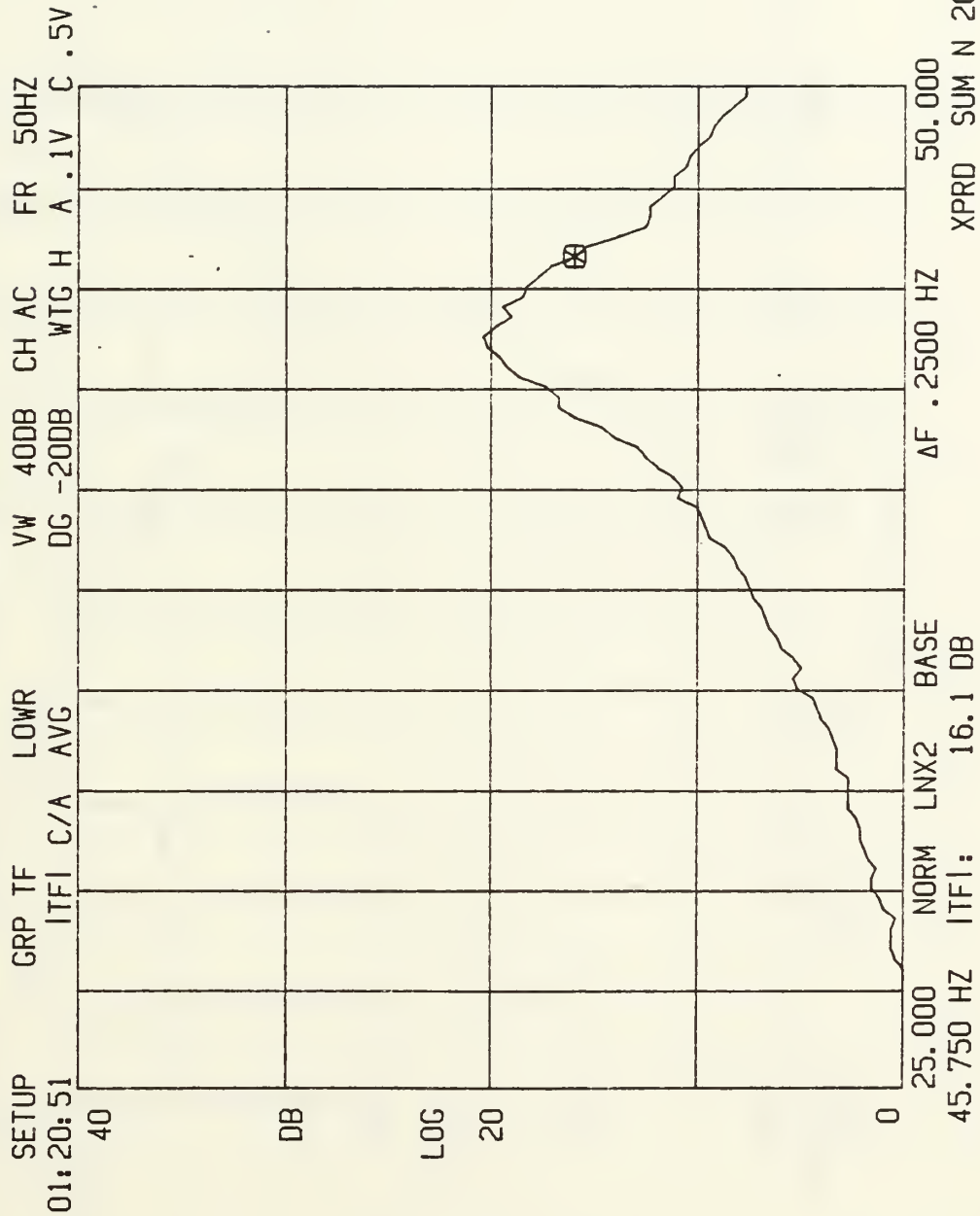
AB-7 1000 Deg C & FC

SETUP 01:04:28
GRP TF
ITFI C/A
LOWR
VW 40DB
CH AC
WTG H A .1V C .5V



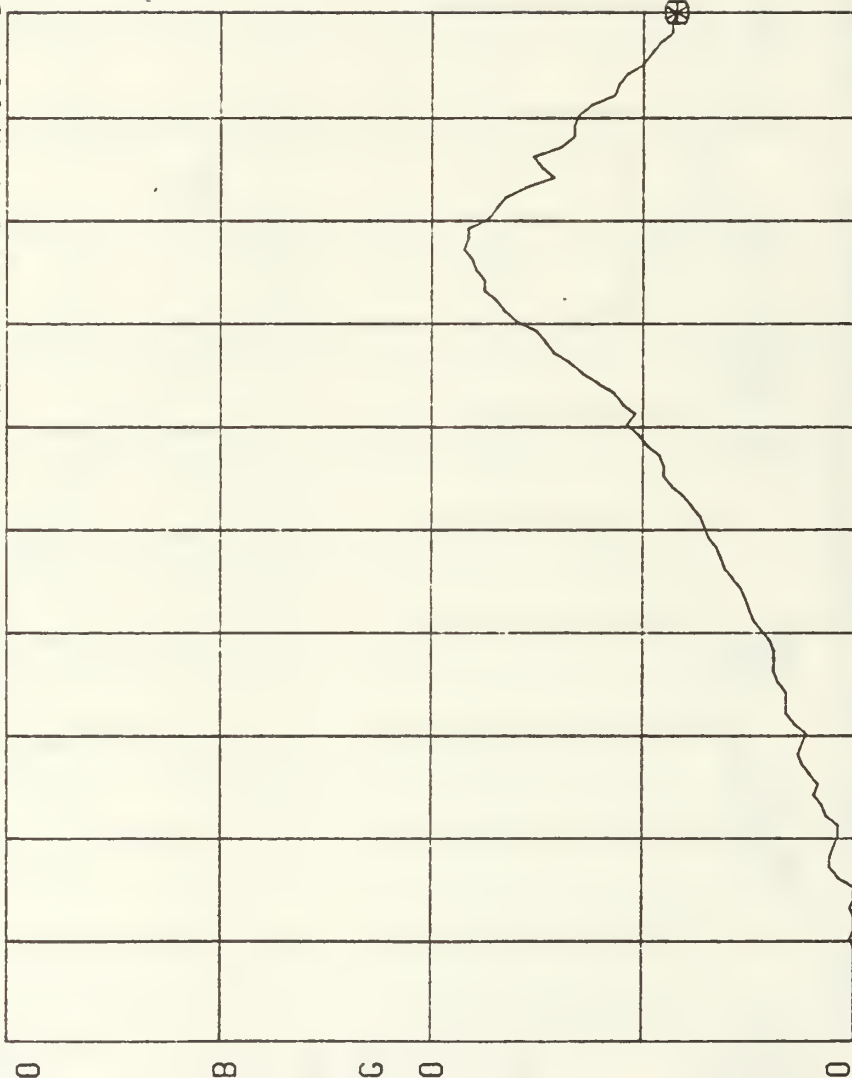
25.000 44.000 HZ
NORM LNX2
ITFI: 10.0 DB
BASE
ΔF .2500 HZ
XPRD SUM N 200

AB-8 1000 Deg C & FC



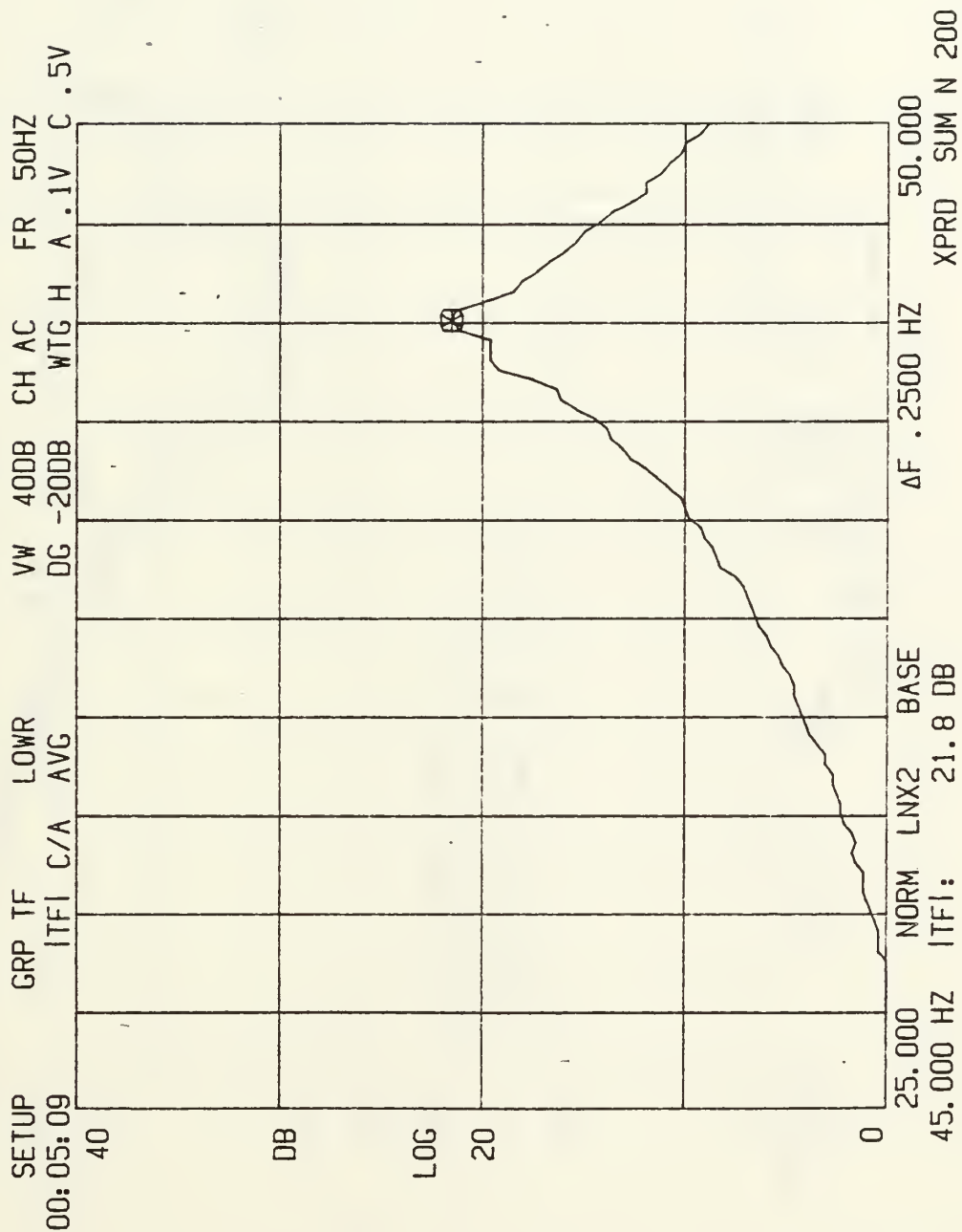
AB-10 950 Deg C & FC

SETUP 01:28:47
GRP TF
ITFI C/A
LOWR
VW 40DB CH AC FR 50HZ
DG -20DB WTG H A .1V C .5V



25.000 NORM LNX2 BASE
50.000 HZ ITFI: 8.6 DB
ΔF .2500 HZ XPRD SUM N 200

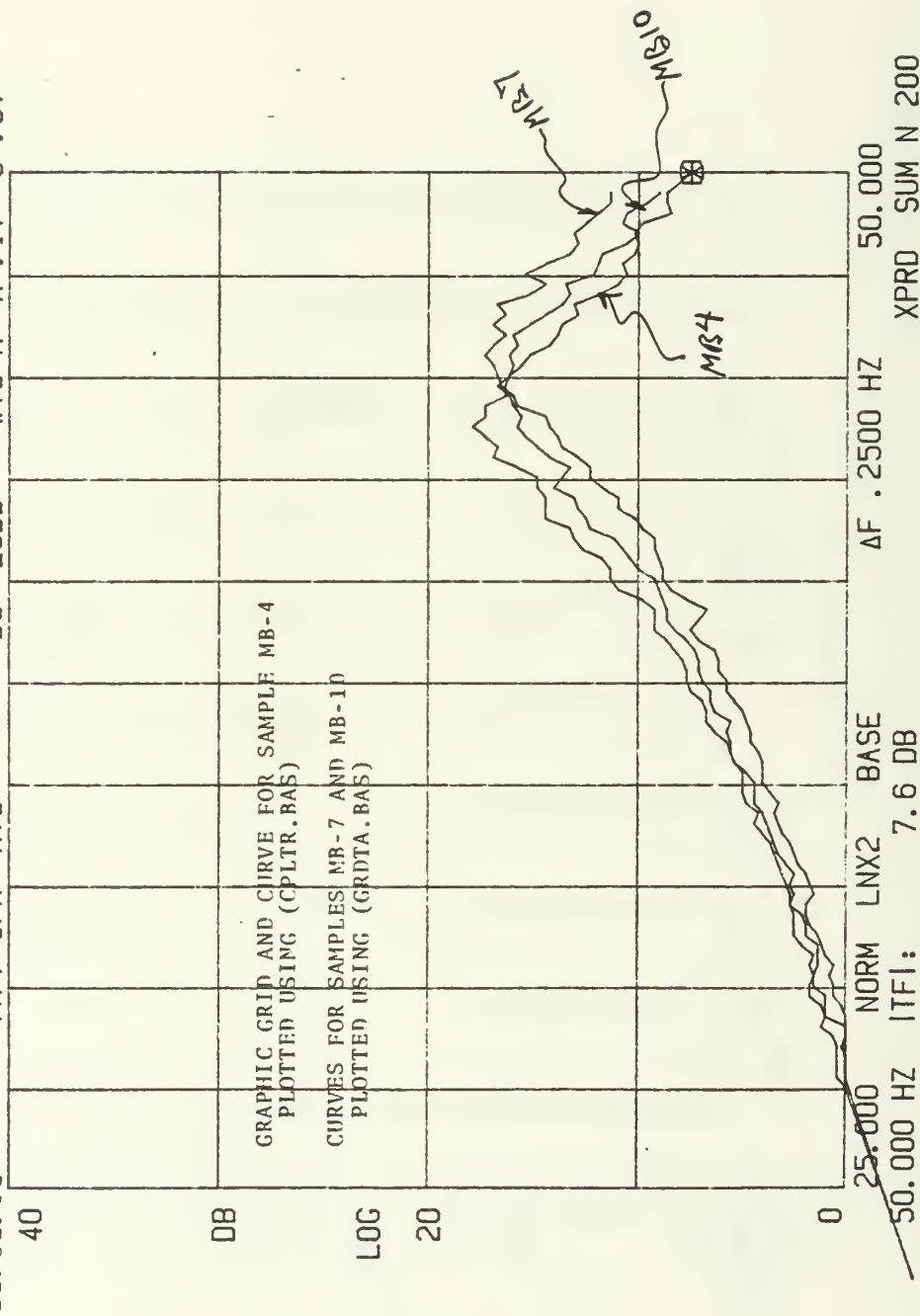
AP-11 950 Deg C & FC



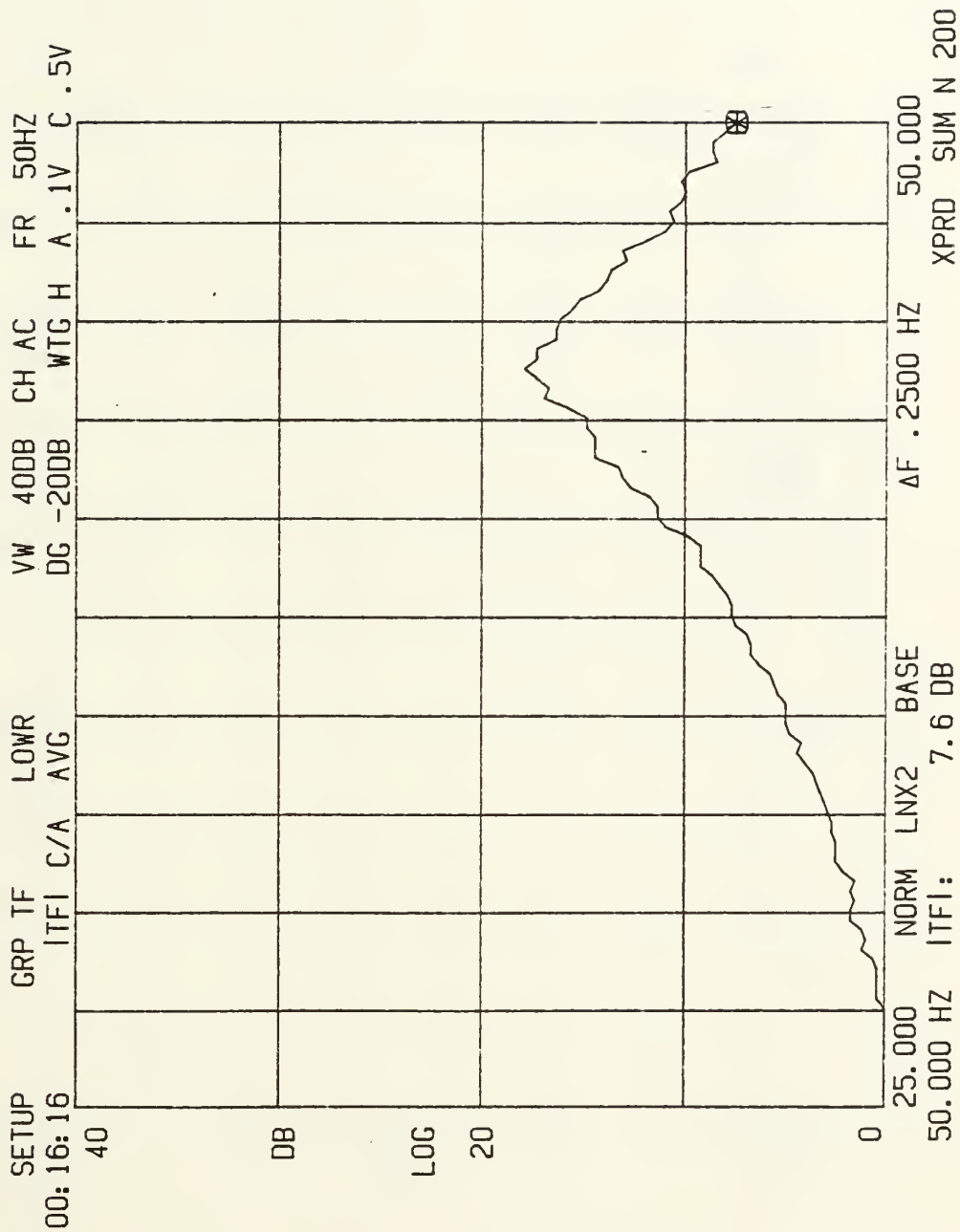
```

SETUP          GRP TF      LOWR      VW 400B CH AC  FR 50HZ
00:16:16      ITFI C/A  AVG  DG -200B WTC H A .1V C .5V

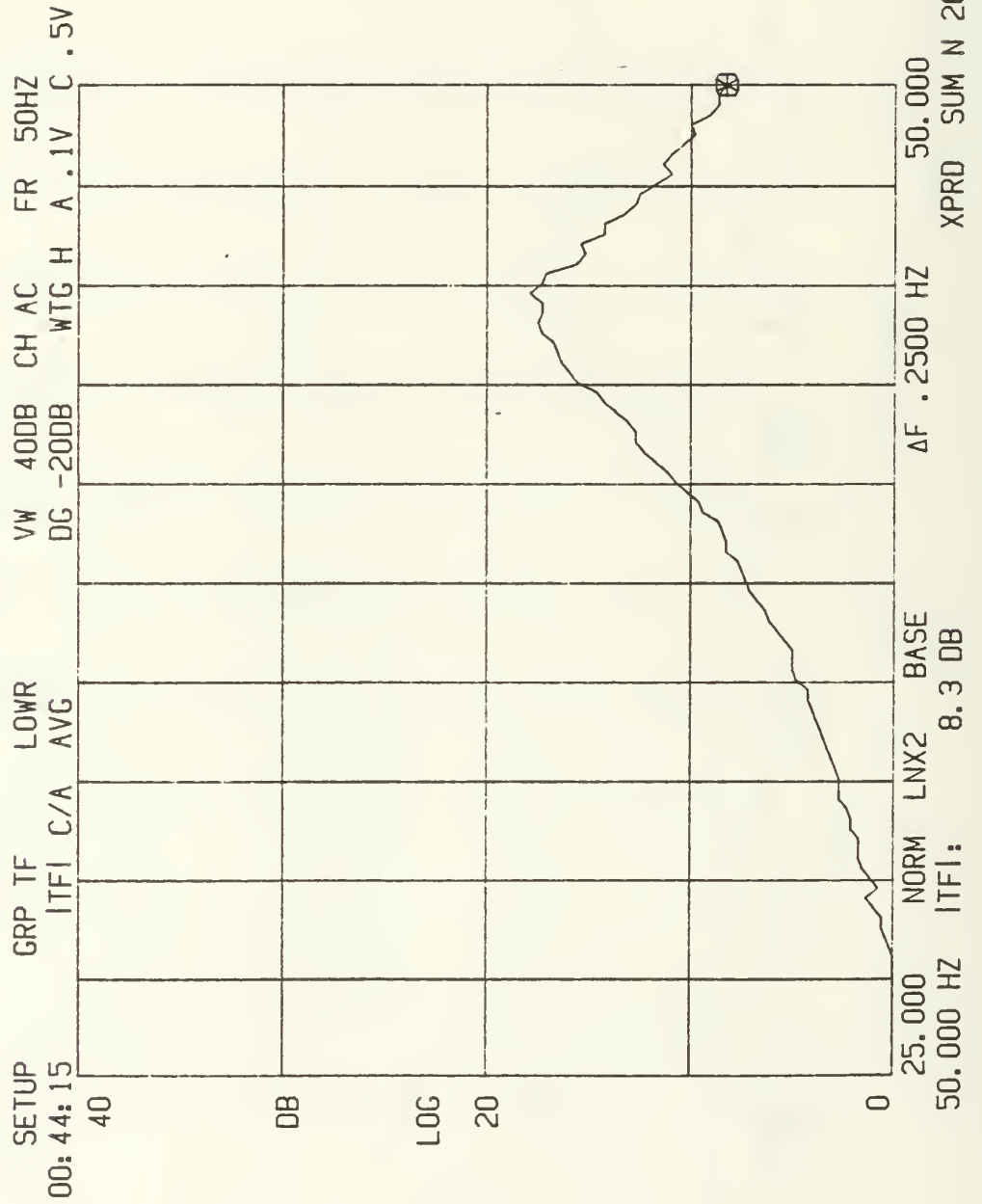
```



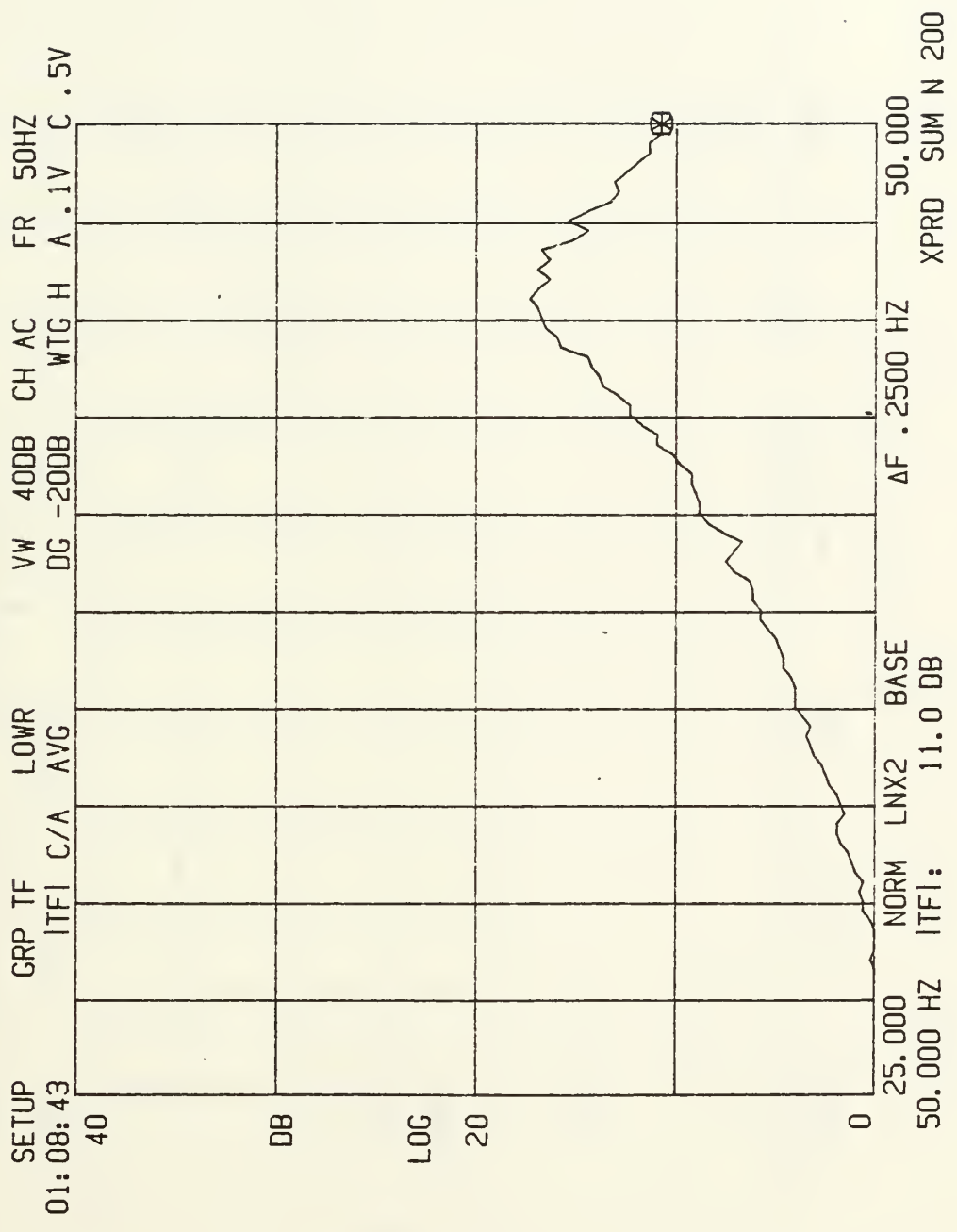
MB-4 1050 Deg C & FC



MB-5 1050 Deg C & FC

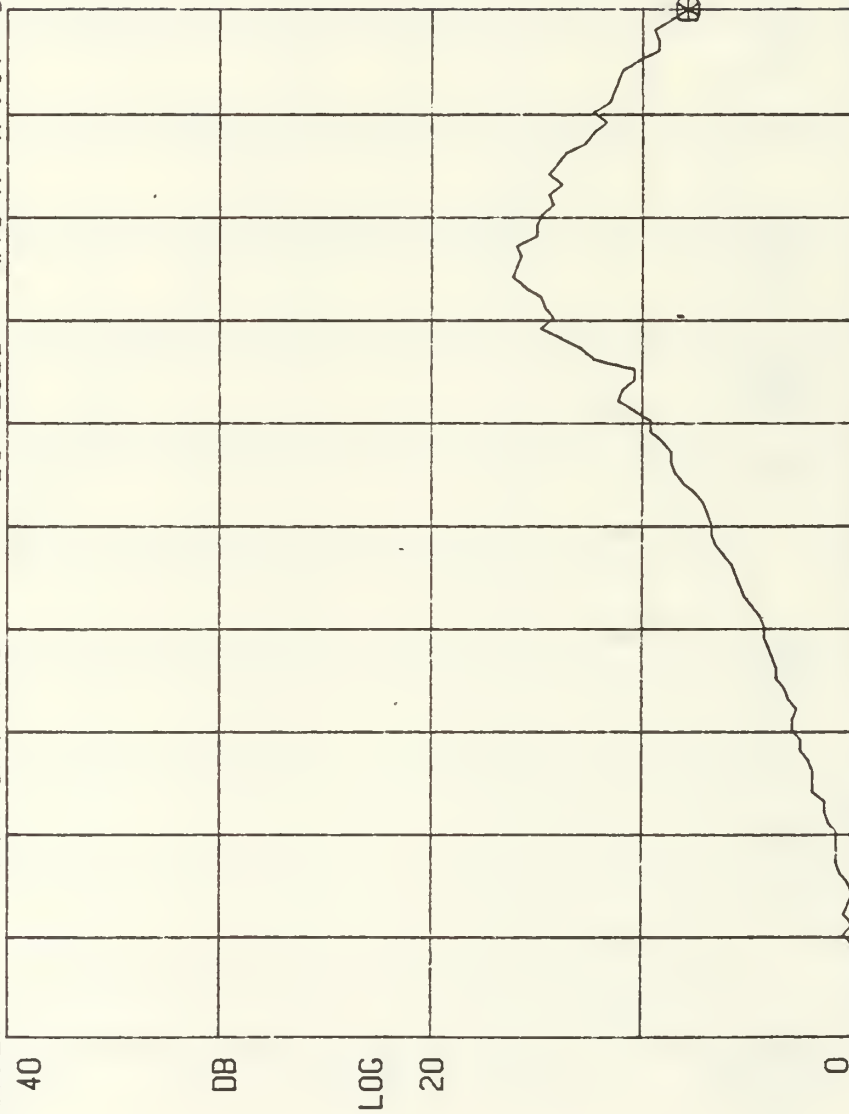


MB-7 1000 Deg C & FC



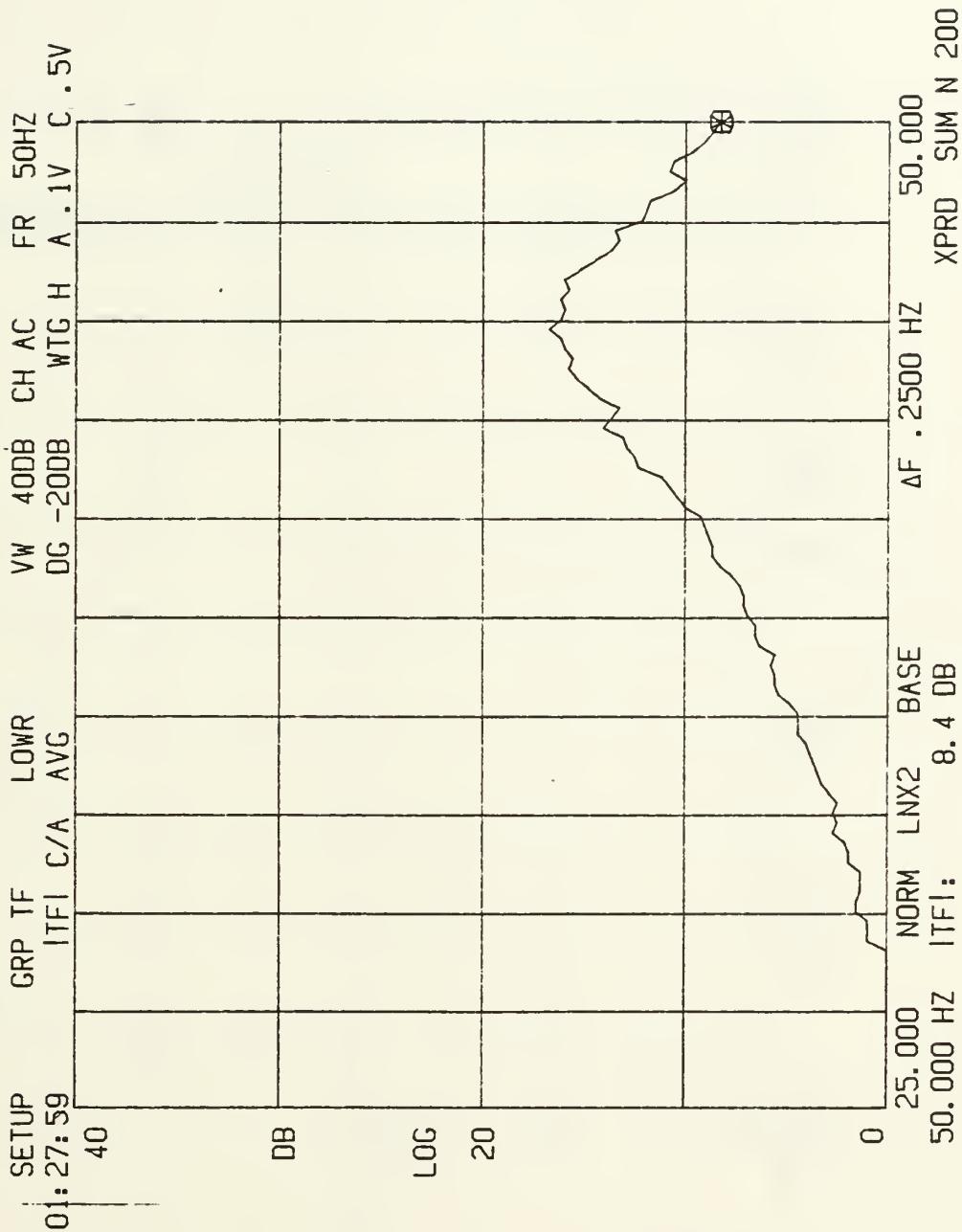
MB-8 1000 Deg C & FC

SETUP 01:15:27 GRP TF ITFI C/A LOWR VW 40DB CH AC FR 50HZ
01:15:27 ITFI C/A AVG DG -20DB WTC H A .1V C .5V

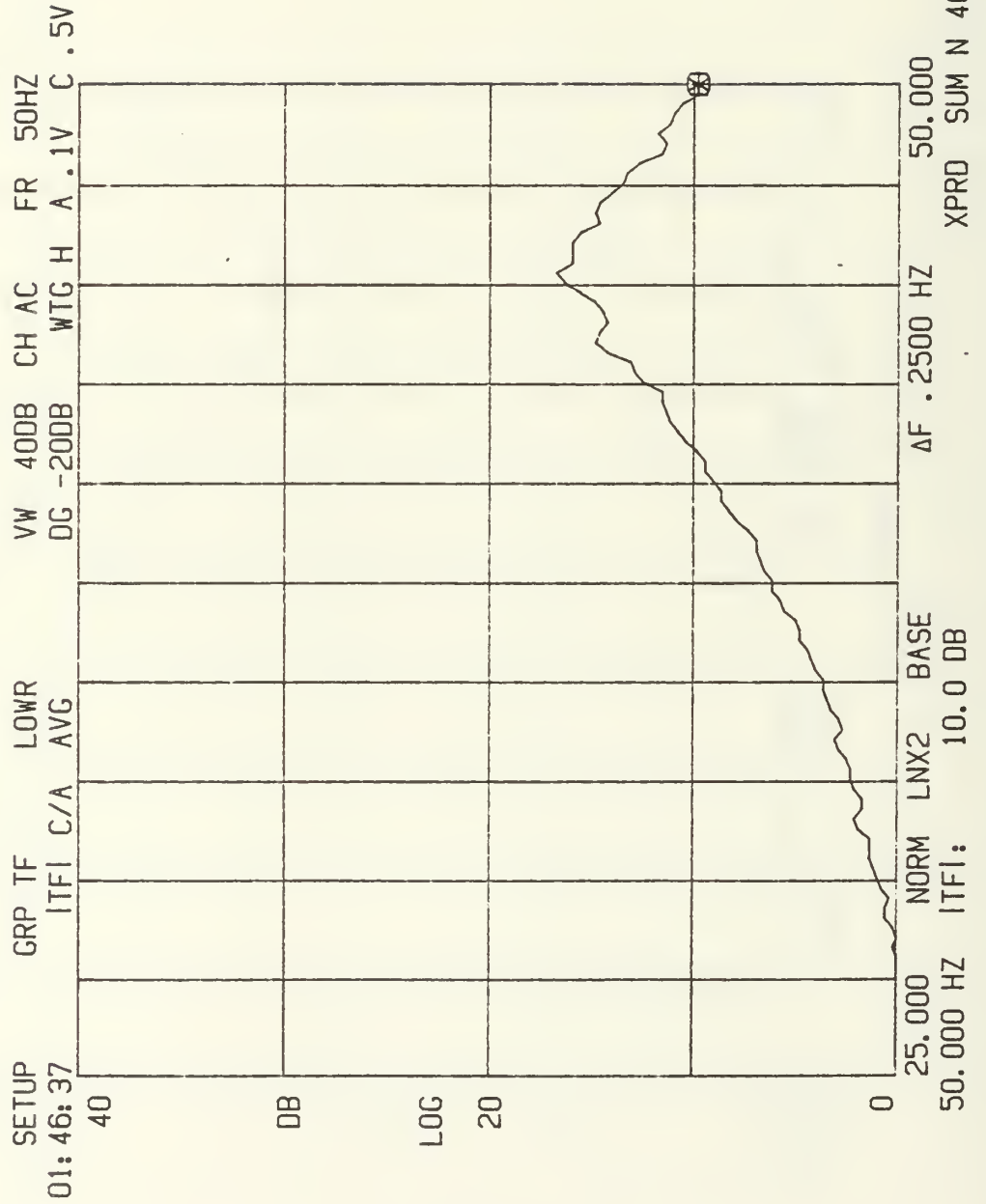


25.000 NORM LNX2 BASE 50.000
50.000 HZ ITFI: 8.0 DB XPRD SUM N 200

MB-10 950 Deg C & FC



MR-11 950 Peg C & FC



APPENDIX D

NUMERICAL SDC AND DC PROGRAM RESULTS

RESULTS FOR alfc1100.xyc

SDC = 62.19728 Percent

DC = 4.949503E-02

PLOTTER COORD YMAX(Abs) = 103

X(0) = 1023 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.6523

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT OSCREEN

RESULTS FOR a2fc1100.xyc

SDC = 40.32938 Percent

DC = .0320931

PLOTTER COORD YMAX(Abs) = 132

X(0) = 1727 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.6523

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT OSCREEN

RESULTS FOR a4fc1050.xyc

SDC = 52.9629 Percent

DC = 4.214654E-02

PLOTTER COORD YMAX(Abs) = 106

X(0) = 1407 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.6523

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT OSCREEN

RESULTS FOR a5fc1050.xyc

SDC = 66.83013 Percent

DC = 5.318173E-02

PLOTTER COORD YMAX(Abs) = 95

X(0) = 1087 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.6523

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT OSCREEN

RESULTS FOR a7fc1000.xyc

SDC = 66.34463 Percent

DC = 5.279538E-02

PLOTTER COORD YMAX(Abs) = 106

X(0) = 1023 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.6523

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT OSCREEN

RESULTS FOR a8fc1000.xyc

SDC = 50.58213 Percent

DC = 4.025198E-02

PLOTTER COORD YMAX(Abs) = 124

X(0) = 1471 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.6523

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT OSCREEN

RESULTS FOR a10fc950.xyc

SDC = 46.86655 Percent

DC = 3.729521E-02

PLOTTER COORD YMAX(Abs) = 114

X(0) = 1407 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.6523

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT 0SCREEN

RESULTS FOR a11fc950.xyc

SDC = 42.84997 Percent

DC = 3.409892E-02

PLOTTER COORD YMAX(Abs) = 130

X(0) = 1535 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.6523

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT 0SCREEN

RESULTS FOR m4fc1050.xyc

SDC = 62.94721 Percent

DC = .0500918

PLOTTER COORD YMAX(Abs) = 111

X(0) = 1471 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.01912

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT 0SCREEN

RESULTS FOR m5fc1050.xyc

SDC = 60.23935 Percent

DC = 4.793695E-02

PLOTTER COORD YMAX(Abs) = 111

X(0) = 1343 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.01912

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT 0SCREEN

RESULTS FOR m7fc1000.xyc

SDC = 51.8725 Percent

DC = 4.127883E-02

PLOTTER COORD YMAX(Abs) = 108

X(0) = 1535 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.01912

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT OSCREEN

RESULTS FOR m8fc1000.xyc

SDC = 63.66265 Percent

DC = 5.066113E-02

PLOTTER COORD YMAX(Abs) = 102

X(0) = 1407 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.01912

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT OSCREEN

RESULTS FOR m10fc950.xyc

SDC = 53.54609 Percent

DC = 4.261063E-02

PLOTTER COORD YMAX(Abs) = 105

X(0) = 1599 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.01912

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT 0SCREEN

RESULTS FOR m11fc950.xyc

SDC = 55.69478 Percent

DC = .0443205

PLOTTER COORD YMAX(Abs) = 105

X(0) = 1599 X(MAX) = 7231

SDC/DC CORRECTION FACTOR IS 2.01912

Type any key + <RETURN> to ReEnter the SDC/DC factor

1LIST 2RUN 3LOAD" 4SAVE" 5CONT 6,"LPT1 7TRON 8TROFF9EXIT 0SCREEN

APPENDIX E

SIGNAL ANALYZER INTERFACE PROGRAM CODE


```

100 REM ***** <MENU.BAS> PROGRAM *****
120 REM This is the MAIN MENU for all the Signal Analyzer utility programs.
140 CLS : BEEP : BEEP : REM Clear screen.
160 PRINT " *****"
180 PRINT " **                SIGNAL ANALYZER INTERFACE PROGRAM                **"
200 PRINT " **                MAIN OPTIONS MENU                **"
220 PRINT " **"
240 PRINT " ** <MCNFG.BAS> ..... 1 **"
260 PRINT " ** <FPLOT.BAS> ..... 2 **"
280 PRINT " ** <PRPLOT.BAS> ..... 3 **"
300 PRINT " ** <CPLTR.BAS> ..... 4 **"
320 PRINT " ** <INTDTA.BAS> ..... 5 **"
340 PRINT " ** <GRDTA.BAS> ..... 6 **"
360 PRINT " ** <SCRNDTA.BAS> ..... 7 **"
380 PRINT " ** <ITERPLOT.BAS> ..... 8 **"
400 PRINT " ** <DAMPCALC.BAS> ..... 9 **"
420 PRINT " ** <GRAPHXYC.BAS> ..... 10 **"
440 PRINT " ** EXIT THIS MENU .....ANY OTHER KEY **"
460 PRINT " **"
480 PRINT " **"
500 PRINT " **"
520 PRINT " **"
540 PRINT " ** PERKINS/PATCH MASTERS THESIS (NAVPGSCOL) **"
560 PRINT " ** COPYRIGHT AUGUST 20, 1987 UNITED STATES NAVY **"
580 PRINT " *****"
600 LOCATE 18, 18 : INPUT "CHOICE ";ANSS
620 LOCATE 18,30 : PRINT "OK!" : LOCATE 18,35
640 IF ANSS = "1" THEN RUN "MCNFG"
660 IF ANSS = "2" THEN RUN "FPLOT"
680 IF ANSS = "3" THEN RUN "PRPLOT"
700 IF ANSS = "4" THEN RUN "CPLTR"
720 IF ANSS = "5" THEN RUN "INTDTA"
740 IF ANSS = "6" THEN RUN "GRDTA"
760 IF ANSS = "7" THEN RUN "SCRNDTA"
780 IF ANSS = "8" THEN RUN "ITERPLOT"
800 IF ANSS = "9" THEN RUN "DAMPCALC"
820 IF ANSS = "10" THEN RUN "GRAPHXYC"
840 CLS : PRINT : PRINT " EXITING MAIN MENU... "
860 END

```

```

100 REM ***** gpib-pc lead-in program lines *****
120 CLEAR ,59504!:REM BASIC Declarations
140 IBINIT1 = 59504!
160 IBINIT2 = IBINIT1 + 3:REM Lines 120 through 220 MUST be included in
180 BLOAD "bib.m",IBINIT1
200 CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,
    IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,
    IBWRTF)
220 CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,
    IBRD,IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,
    IBWRTIA,IBSTA%,IBERR%,IBCNT%)
240 REM ***** gpib-pc lead-in program lines end here *****
260 KEY 9, "EXIT" : ON KEY (9) GOSUB 1740 : KEY (9) ON: REM Interrupt trap.
280 REM ---- program Machine Configuration <MCNFG.BAS> ----
300 DIM A$(1000)
320 CLS : SOUND 900, 8 : SOUND 880, 6
340 PRINT "***** Machine Configuration Program <MCNFG.BAS> *****"
360 PRINT "*** This program can store signal analyzer machine configuration ***"
380 PRINT "*** codes obtained originally from the analyzer itself. The ***"
400 PRINT "*** program can also set up the signal analyzer, using any ***"
420 PRINT "*** configuration data files previously saved to computer disc. ***"
440 PRINT "*****"
460 PRINT "*** Ensure that the Signal Analyzer is connected and ON ***"
480 PRINT "*** and that its GPIB address is 25. ***"
500 PRINT "*****"
520 DEVS = "DEV1" : CNT% = 1200 : AT$ = " FPKEY 8,47 " : CMD1$ = "mcnfg?"
540 CMD2$ = "mcnfg "
560 PRINT : PRINT "Type 1 to obtain & store the current configuration. "
580 PRINT "Type 2 to set up analyzer with an existing config'tn file. "
600 PRINT: INPUT " 1 or 2 ... "; ANSS
620 REM Following three lines are traps for invalid/valid keyboard responses.
640 IF ANSS = "1" THEN 720
660 IF ANSS = "2" THEN 1120
680 GOTO 320
700 REM ***** start program section to obtain & store analyzer config'tn *****
720 CALL IBFIND (DEVS,DV%)
740 CALL IBCMD (DV%, AT$ )
760 CALL IBWRT (DV%, CMD1$)
780 CALL IBRDI (DV%, A$(1), CNT%)
800 CLS: PRINT : PRINT "This is a sample of the analyzer config'tn data ... "
820 FOR I = 1 TO 400: PRINT A$(I);: NEXT I
840 PRINT : PRINT "What file name for disc storage? "
860 SOUND 900, 8 : SOUND 880, 6
880 PRINT "Note: The file designation must be cfg (ie); filename.cfg "
900 PRINT "Type <RETURN> to bypass disc storage. "
920 PRINT : INPUT "Filename.cfg ...";FILES$
940 IF FILES$ = "" THEN 1580
960 IF LEN(FILES$) > 12 THEN 840 : REM Limits filename length to < 12
980 IF RIGHTS(FILES$,3) = "CFG" THEN 1020
1000 IF RIGHTS(FILES$,3) <> "cfg" THEN 840
1020 CLS: PRINT : PRINT "Storing analyzer config'tn data under filename ";FILES$
1040 PRINT : PRINT "Please wait... "
1060 OPEN "c:\gpib-pc\" + FILES$ FOR OUTPUT AS #1
1080 FOR J = 1 TO 600 : PRINT #1, USING "#####"; A$(J); : NEXT J
1100 CLOSE #1 : GOTO 1580

```

```

1120 REM ***** start of program section to use existing disc file *****
1140 ON ERROR GOTO 1700 : CLS : REM No file error trap & clear screen.
1160 PRINT : FILES "*.cfg" : SOUND 900, 8 : SOUND 880, 6
1180 PRINT : PRINT "What file name for retrieval from disc?"
1200 INPUT "Note: The file designation must be cfg (ie); filename.cfg "; FILES$
1220 IF RIGHTS(FILES$,3) = "CFG" THEN 1260
1240 IF RIGHTS(FILES$,3) <> "cfg" THEN 1160
1260 PRINT : PRINT "Opening file ";FILES$;" ...Please wait. "
1280 OPEN "c:\gpib-pc\" + FILES$ FOR INPUT AS #1
1300 FOR J = 1 TO 600 : IF EOF(1) THEN 1320 : INPUT #1, A$(J) : NEXT J
1320 CLOSE #1 :CLS :PRINT : PRINT "Sample contents of file ";FILES$;" are ... "
1340 FOR I = 1 TO 400 : PRINT A$(I); : NEXT I
1360 PRINT : PRINT : SOUND 900, 8 : SOUND 880, 6
1380 INPUT "Type yes to set up signal analyzer using this file. ";ANSS$
1400 IF LEFT$(ANSS$,1) = "y" THEN 1440
1420 IF LEFT$(ANSS$,1) <> "Y" THEN 1580
1440 CALL IBFIND (DV$, DV%)
1460 CALL IBCMD (DV%, AT$)
1480 CALL IBWRT (DV%, CMD2$)
1500 CALL IBWRTI (DV%, A$(1), CNT%)
1520 PRINT : INPUT "Type KK + <return> to reset using same file. ";ANSS$
1540 IF ANSS$ = "KK" THEN 1440
1560 IF ANSS$ = "kk" THEN 1440
1580 CLS : SOUND 760,6 : PRINT : INPUT "Type yes to run program again. ";ANSS$
1600 IF LEFT$(ANSS$,1) = "y" THEN 100
1620 IF LEFT$(ANSS$,1) = "Y" THEN 100
1640 RUN "MENU.BAS"
1660 END
1680 REM ***** No existing file error trap *****
1700 IF ERR = 53 THEN PRINT "File not found; try again. " : RESUME 1120
1720 ON ERROR GOTO 0
1740 REM ***** INTERRUPT SUBROUTINE *****
1760 BEEP : BEEP
1780 CLS : LOCATE 4, 1
1800 PRINT : PRINT "PROGRAM INTERRUPT... "
1820 PRINT : PRINT "Type <RETURN> to resume this program section."
1840 PRINT : PRINT "Type <KK> to start this program section over."
1860 PRINT : PRINT "Type any other key + <RETURN> to exit to main menu."
1880 PRINT : INPUT ANSS$
1900 IF ANSS$ = "" THEN RETURN
1920 IF ANSS$ = "KK" THEN 100
1940 IF ANSS$ = "kk" THEN 100
1960 RUN "MENU.BAS"

```

```

100 REM ***** GPIB-PC PROGRAM HEADER *****
120 CLEAR ,59504!:REM BASIC Declarations
140 IBINIT1 = 59504!
160 IBINIT2 = IBINIT1 + 3:REM Lines 120 through 220 MUST be included
    in your program.
180 BLOAD "bib.m",IBINIT1
200 CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,
    IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,
    IBWRTF)
220 CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,
    IBRD,IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,
    IBWRTIA,IBSTA%,IBERR%,IBCNT%)
240 REM ***** END OF GPIB-PC PROGRAM HEADER *****
260 DIM A$(10000)
280 KEY 9, "EXIT" : ON KEY (9) GOSUB 1420 : KEY (9) ON :REM F9 key interrupt.
300 CLS : PRINT : PRINT : REM Program Name <FLOT.BAS>
320 ON ERROR GOTO 1360 : REM No existing file trap.
340 PRINT "***** PROGRAM <FLOT.BAS> *****"
360 PRINT "*** This program files signal analyzer screen images in disc ***"
380 PRINT "*** files named by the operator. Each analyzer screen image is ***"
400 PRINT "*** stored as an integer array. Each element of the integer ***"
420 PRINT "*** array represents two ASCII code characters from the HP ***"
440 PRINT "*** plotter language. (Ref: HP Plotter Prog. Manual, pg. 1-8 & 9)***"
460 PRINT "*** Please ensure that the signal analyzer is turned on and ***"
480 PRINT "*** that it's GPIB address is twenty-five (25). ***"
500 PRINT "*****"
520 PRINT "*** NOTE: Use <MCNFG.BAS> to store Signal Analyzer machine ***"
540 PRINT "*** configuration files identified as 'filename.cfg' ***"
560 PRINT "*****"
580 SOUND 2100, 10 : SOUND 1970, 9
600 PRINT : PRINT "What filename do you wish to specify? "
620 PRINT "Note: File designations must be dta (i.e.); filename.dta "
640 PRINT : INPUT "Type your filename.dta";FILES
660 IF LEN(FILES) > 12 THEN 580 :REM Limit filename length to 12 characters.
680 IF RIGHT$(FILES,3) = "DTA" THEN 720
700 IF RIGHT$(FILES,3) <> "dta" THEN 580
720 V% = 0
740 DEV$ = "DEV1"
760 CNT% = 11000
780 CMD1$ = "PLOT? "
800 CALL IBFIND (DEV$,DV%)
820 CALL IBTMO (DV%, V%)
840 CALL IBWRT (DV%, CMD1$)
860 CALL IBRDI (DV%, A$(0), CNT%)
880 PRINT:PRINT "The following matrices of integers is a sample of how "
    : PRINT " the analyzer data looks stored on the disc... "
900 FOR N = 1 TO 2400: NEXT N : PRINT : REM This is a time delay line.
920 PRINT "SAMPLE DATA... SAMPLE DATA... SAMPLE DATA... "
940 PRINT "SAMPLE DATA... SAMPLE DATA... SAMPLE DATA... "
960 FOR I = 1 TO 220: PRINT A$(I); : NEXT I
980 PRINT : PRINT : PRINT "Storing screen data to disc... "
1000 OPEN "C:\GPIB-PC\" + FILES FOR OUTPUT AS #1
1020 FOR J = 1 TO 10000 STEP 4
1040 PRINT#1, USING "#####"; A$(J); A$(J+1); A$(J+2); A$(J+3);
1060 IF A$(J) + A$(J+1) + A$(J+2) + A$(J+3) = 0 THEN 1120

```



```

1080     PRINT "+";
1100 NEXT J
1120 CLOSE #1
1140 PRINT : PRINT "Screen data stored on disc under filename ";FILES$
1160 PRINT : PRINT FILES$;" disc file filled with ";J;"elements... "
1180 PRINT : PRINT "Disc file ";FILES$;" closed ... "
1200     ERASE AX : REM Erase prior contents of AX(matrix) to prep for reuse.
1220 PRINT:PRINT "Type yes to run the program again to file another signal"
1240 INPUT " analyzer screen";ANSS
1260 IF LEFT$(ANSS,1) = "y" THEN 100
1280 IF LEFT$(ANSS,1) = "Y" THEN 100
1300     RUN "MENU.BAS"
1320 END
1340 REM ***** No file/Bad filename error trap routine *****
1360     IF ERR = 64 THEN PRINT "Bad file name; try again. "
1380     IF ERR = 50 THEN PRINT "Filename is too long; try again. "
        : RESUME 340
1400     ON ERROR GOTO 0
1420 REM ***** SUBROUTINE FOR F9 MENU ESCAPE SEQUENCE *****
1440     BEEP : BEEP
1460     CLS : LOCATE 4, 1
1480     PRINT "PROGRAM INTERRUPT... "
1500     PRINT : PRINT "Type <RETURN> to resume this program section."
1520     PRINT : PRINT "Type <KK> to start this program section over again."
1540     PRINT : PRINT "Type any other key + <RETURN> to exit to main menu."
1560     PRINT : INPUT ANSS
1580         IF ANSS = "" THEN RETURN
1600         IF ANSS = "KK" THEN 100
1620         IF ANSS = "kk" THEN 100
1640         RUN "menu.bas"

```



```

100 REM ***** Program Name <PRPLOT.BAS> *****
120 CLEAR : ON ERROR GOTO 1100 : REM Zero variables & set no existing file
    trap.
140 DIM A%(10000) : CLS : REM Dimension A%(matrix) & clear screen.
160 KEY 9, "EXIT" : ON KEY (9) GOSUB 1140 : KEY (9) ON : REM Interrupt trap.
180 REM This program outputs the contents of the disc file designated by the
200 REM operator to the line printer in the format in which it is stored.
220 PRINT "***** Program Name <PRPLOT.BAS> *****"
240 PRINT "*** This program prints the contents of a GPIB disc file on the ***"
260 PRINT "*** line printer. The integer disc file is printed in the same ***"
280 PRINT "*** format in which it was stored. Any integer disc file ***"
300 PRINT "*** containing less than 10000 integer elements can be printed. ***"
320 PRINT "*****"
340 PRINT : INPUT "Type <RETURN> to continue... ", ANSS
360 CLS : PRINT "Standard files on this disc are..."
380 PRINT : FILES "*.dta" : FILES "*.CFG" : FILES "*.xyc"
400 SOUND 2100, 10 : SOUND 1970, 9.600001
420 PRINT : PRINT "What filename? "
440 PRINT "Please include a file designation (i.e.); filename.xxx "
460 PRINT " where xxx is the designation. "
480 PRINT "[---- NON-INTEGGER files will not correctly load. ----]"
500 PRINT : INPUT "Filename.xxx";FILES
520 IF RIGHTS(FILES,3) = "bas" THEN 220
540 IF RIGHTS(FILES,3) = "BAS" THEN 220
560 IF RIGHTS(FILES,3) = "EXE" THEN 220
580 IF RIGHTS(FILES,3) = "exe" THEN 220
600 IF RIGHTS(FILES,3) = "COM" THEN 220
620 IF RIGHTS(FILES,3) = "com" THEN 220
640 IF RIGHTS(FILES,3) = "BAT" THEN 220
660 IF RIGHTS(FILES,3) = "bat" THEN 220
680 PRINT : PRINT "Reading the contents of disc file ";FILES : PRINT
700 OPEN "c:\gpiB-pc\" + FILES FOR INPUT AS #1
720 FOR I = 1 TO 10000 STEP 2
740 IF EOF(1) THEN 840
760 INPUT#1, A%(I), A%(I+1)
780 IF A%(I) + A%(I+1) = 0 THEN 840
800 PRINT "+";
820 NEXT I
840 CLOSE #1
860 PRINT : PRINT : PRINT "Sending file ";FILES;" to the line printer. "
880 FOR J = 1 TO 10000
900 PRINT USING "#####";A%(J);
920 LPRINT USING "#####";A%(J);
940 IF A%(J) + A%(J+1) + A%(J+2) = 0 THEN 980
960 NEXT J
980 PRINT : INPUT "Type yes to print another file"; ANSS
1000 IF LEFT$(ANSS,1) = "y" THEN 100
1020 IF LEFT$(ANSS,1) = "Y" THEN 100
1040 RUN "MENU.BAS"
1060 END
1080 REM ***** NO EXISTING FILE ERROR TRAP *****
1100 IF ERR = 53 THEN PRINT "File not found; try again. " : RESUME 220
1120 ON ERROR GOTO 0
1140 REM ***** SUBROUTINE FOR F9 KEY PROGRAM INTERRUPT *****
1160 CLS : LOCATE 4, 1 : BEEP : BEEP

```

```
1180 PRINT : PRINT "PROGRAM INTERRUPT... "  
1200 PRINT : PRINT "Type <RETURN> to resume this program section."  
1220 PRINT : PRINT "Type <KK> to start this program section over."  
1240 PRINT : PRINT "Type any other key + <RETURN> to exit to main menu."  
1260 PRINT : INPUT ANSS  
1280 IF ANSS = "" THEN RETURN  
1300 IF ANSS = "KK" THEN 100  
1320 IF ANSS = "kk" THEN 100  
1340 RUN "menu.bas"
```

```

100 REM ***** interface board heading *****
120 CLEAR ,59504!:REM BASIC Declarations
140 IBINIT1 = 59504!
160 IBINIT2 = IBINIT1 + 3:REM Lines 120 through 220 MUST be included
    in your program.
180 BLOAD "b1b.m",IBINIT1
200 CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,
    IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,
    IBWRTF)
220 CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,
    IBRD,IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,
    IBWRTIA,IBSTA%,IBERR%,IBCNT%)
240 REM ***** end of IB program heading *****
260 REM ---- program name Computer Plotter <CPLTR.BAS> ----
280 DIM A%(10000)
300 KEY 9, "EXIT" : ON KEY (9) GOSUB 1500 : KEY (9) ON : REM Interrupt trap.
320 CLS : SOUND 800, 10: SOUND 780, 8
340 PRINT "***** Program Computer Plotter <CPLTR.BAS> *****"
360 PRINT "*** This program uses the HP-plotter to draw a graph using data ***"
380 PRINT "*** from a computer disc file selected by the operator. The file ***"
400 PRINT "*** chosen must contain an image from the Scientific Atlanta ***"
420 PRINT "*** signal analyzer that was saved to disc in integer format. ***"
440 PRINT "*** The file designation must be {.dta}, (i.e.) filename.dta ***"
460 PRINT "*** Please ensure that the plotter is connected and turned on. ***"
480 PRINT "*****"
500 ON ERROR GOTO 1460 : REM No existing file trap.
520 PRINT : INPUT "Type <RETURN> to continue... ", ANS$
540 CLS
560 PRINT : FILES "*.dta"
580 PRINT : INPUT "What file name contains your graph";FILES
600 IF RIGHTS(FILES,3) = ".dta" THEN 640
620 IF RIGHTS(FILES,3) <> ".DTA" THEN 320
640 CLS : LOCATE 4, 1
660 PRINT "Loading disc file ";FILES;" ... Please wait... "
680 CNT% = 10500
700 OPEN "c:\gplib-pc\" + FILES FOR INPUT AS #1
720 FOR I = 1 TO 10000 STEP 2
740 IF EOF(1) THEN 880
760 INPUT#1, A%(I), A%(I+1)
780 IF A%(I) + A%(I+1) = 0 THEN 880
800 PRINT "+";
820 X = CSRLIN : IF X <= 22 THEN 860
840 CLS : LOCATE 4, 1 : PRINT "Still loading ";FILES;
860 NEXT I
880 CLOSE #1
900 REM Program section to initiate HP-plotter and select pen.
920 PRINT : PRINT : PRINT "Plotting the disc file ";FILES;
940 CMD1$ = ";;IN;;"
960 CMD2$ = ";;SP;;SP;;SP 1;;"
980 CMD3$ = ";;PA1100,2100;;"
1000 CMD4$ = ";;PU;;PU;;SP;;"
1020 DEV$ = "hppltr"
1040 CALL IBFIND (DEV$, DV%)
1060 CALL IBCMD (DV%, CMD1$)
1080 CALL IBWRT (DV%, CMD2$)

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```

1100 CALL IBWRT (DV%, CMD3$)
1120 REM program section to send data to plotter
1140 V% = 0
1160 CALL IBTMO (DV%, V%)
1180 CALL IBWRTI (DV%, A%(0), CNT%)
1200 CALL IBWRT (DV%, CMD4$)
1220 PRINT : PRINT : PRINT "data bytes written to plotter... "; IBCNT%
1240 PRINT "plotter status... "; IBSTA%
1260 REM program section to end or re-run the program
1280 PRINT : PRINT : PRINT "Type yes to run this program again. "
1300 INPUT "Type K to print the same disc file again. "; ANSS
1320 IF LEFT$(ANSS,1) = "y" THEN 100
1340 IF LEFT$(ANSS,1) = "Y" THEN 100
1360 IF ANSS = "K" THEN 920
1380 IF ANSS = "k" THEN 920
1400 RUN "MENU.BAS"
1420 END
1440 REM ***** No existing file trap *****
1460 IF ERR = 53 THEN PRINT "File not found; try again. " : RESUME 340
1480 ON ERROR GOTO 0
1500 REM ***** KEY (9) INTERRUPT SUBROUTINE *****
1520 CLS : LOCATE 4, 1 : BEEP : BEEP
1540 PRINT : PRINT "PROGRAM INTERRUPT... "
1560 PRINT : PRINT "Type <RETURN> to resume this program section."
1580 PRINT : PRINT "Type <KK> to start this program section over."
1600 PRINT : PRINT "Type any other key + <RETURN> to exit to main menu."
1620 PRINT : INPUT ANSS
1640 IF ANSS = "" THEN RETURN
1660 IF ANSS = "KK" THEN 100
1680 IF ANSS = "kk" THEN 100
1700 RUN "menu.bas"

```

```

100 REM ***** Program Name <INTDTA.BAS> *****
120 CLEAR : ON ERROR GOTO 1580 : REM Clear screen & set no file trap.
140 DIM A$(10000) : REM Dimension A$(matrix).
160 REM ++++++
180 KEY 9, "EXIT" : ON KEY (9) GOSUB 1620 : KEY (9) ON : REM Interrupt trap.
200 REM ++++++
220 REM This program opens a GPIB disc file, reads the integer data into
240 REM memory, then converts that integer data to ASCII characters for
260 REM interpretation. The converted code is displayed on the screen
280 REM and is also sent as output to the line printer.
300 CLS : SOUND 2100, 10 : SOUND 1970, 9.600001
320 PRINT"***** Program Name <INTDTA.BAS> *****"
340 PRINT"** This program converts the integer contents of a GPIB disc file **"
360 PRINT"** into ASCII characters for interpretation. The converted code **"
380 PRINT"** is displayed on the screen and output to the line printer.      **"
400 PRINT"** (Non-integer files will not load.) {Interpretation of output:  **"
420 PRINT"** Plotter language is explained in the HP Plotter Prog. Manual  **"
440 PRINT"** & Signal Analyzer codes in the Sci. Atlanta Operating Manual.}  **"
460 PRINT"*****"
480 PRINT"** NOTE: Type F9 to interrupt program printing operation if the  **"
500 PRINT"** entire decoded file is not desired from the line printer.      **"
520 PRINT"*****"
540 PRINT : INPUT "Type <RETURN> to continue... ", ANSS
560 CLS
580 FILES
600 PRINT : PRINT "What filename? "
620 PRINT "Please include a file designation (i.e.); filename.xxx "
640 PRINT " where xxx is the designation (BAS, BAT, COM or EXE are invalid). "
660 PRINT : INPUT "Filename.xxx";FILES
680 IF RIGHTS(FILES,3) = "bas" THEN 300
700 IF RIGHTS(FILES,3) = "BAS" THEN 300
720 IF RIGHTS(FILES,3) = "EXE" THEN 300
740 IF RIGHTS(FILES,3) = "exe" THEN 300
760 IF RIGHTS(FILES,3) = "COM" THEN 300
780 IF RIGHTS(FILES,3) = "com" THEN 300
800 IF RIGHTS(FILES,3) = "BAT" THEN 300
820 IF RIGHTS(FILES,3) = "bat" THEN 300
840 PRINT : PRINT "Reading the contents of disc file ";FILES : PRINT
860 OPEN "c:\gpiB-pc\" + FILES FOR INPUT AS #1
880 FOR I = 1 TO 10000 STEP 4
900 IF EOF(1) THEN 1000 : REM End of File (EOF) trap.
920 INPUT#1, A$(I), A$(I+1), A$(I+2), A$(I+3)
940 IF A$(I) + A$(I+1) + A$(I+2) + A$(I+3) = 0 THEN 1000
960 PRINT "+";
980 NEXT I
1000 CLOSE #1
1020 PRINT : PRINT : PRINT "The following is sample data from disc file ";FILES
1040 PRINT "-----"
1060 PRINT "SAMPLE DATA... SAMPLE DATA... SAMPLE DATA... "
1080 PRINT "SAMPLE DATA... SAMPLE DATA... SAMPLE DATA... "
1100 PRINT "-----"
1120 FOR I = 1 TO 200: PRINT A$(I); : NEXT I
1140 PRINT
1160 PRINT : PRINT "ASCII interpretations..... "
1180 LPRINT : LPRINT "ASCII interpretations..... "

```



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1200 FOR K = 1 TO 10000 STEP 4
1220 BB = INT(A%(K)/256) : AA = A%(K) - (BB*256)
1240 BB1 = INT(A%(K+1)/256) : AA1 = A%(K+1) - (BB1*256)
1260 BB2 = INT(A%(K+2)/256) : AA2 = A%(K+2) - (BB2*256)
1280 BB3 = INT(A%(K+3)/256) : AA3 = A%(K+3) - (BB3*256)
1300 PRINT A%(K);SPC(1);A%(K+1);SPC(1);A%(K+2);SPC(1);A%(K+3);SPC(2);
1320 LPRINT A%(K);SPC(1);A%(K+1);SPC(1);A%(K+2);SPC(1);A%(K+3);SPC(2);
1340 PRINT CHR$(AA);SPC(1);CHR$(BB);SPC(1);CHR$(AA1);SPC(1);CHR$(BB1);SPC(1);
1360 LPRINT CHR$(AA);SPC(1);CHR$(BB);SPC(1);CHR$(AA1);SPC(1);CHR$(BB1);SPC(1);
1380 PRINT CHR$(AA2);SPC(1);CHR$(BB2);SPC(1);CHR$(AA3);SPC(1);CHR$(BB3)
1400 LPRINT CHR$(AA2);SPC(1);CHR$(BB2);SPC(1);CHR$(AA3);SPC(1);CHR$(BB3)
1420 IF (A%(K) + A%(K+1) + A%(K+2) + A%(K+3) = 0) THEN 1460
1440 NEXT K
1460 PRINT : INPUT "Type yes to print another file"; ANSS
1480 IF LEFT$(ANSS,1) = "y" THEN 100
1500 IF LEFT$(ANSS,1) = "Y" THEN 100
1520 RUN "MENU.BAS"
1540 END
1560 REM ***** No existing file error trap *****
1580 IF ERR = 53 THEN PRINT "File not found; try again. "
      : SOUND 600, 6 : SOUND 580, 4 : RESUME 320
1600 ON ERROR GOTO 0
1620 REM ***** KEY (9) INTERRUPT SUBROUTINE *****
1640 CLS : LOCATE 4, 1 : BEEP : BEEP
1660 PRINT : PRINT "PROGRAM INTERRUPT... "
1680 PRINT : PRINT "Type <RETURN> to resume this program section."
1700 PRINT : PRINT "Type <KK> to start this program section over."
1720 PRINT : PRINT "Type any other key + <RETURN> to exit to main menu."
1740 PRINT : INPUT ANSS
1760 IF ANSS = "" THEN RETURN
1780 IF ANSS = "KK" THEN 100
1800 IF ANSS = "kk" THEN 100
1820 RUN "menu.bas"

```

```

100 REM ***** GPIB Program Header *****
120     CLEAR ,59504!:REM    BASIC Declarations
140     IBINIT1 = 59504!
160     IBINIT2 = IBINIT1 + 3:REM Lines 120 through 220 MUST be included
        in your program.
180     BLOAD "bib.m",IBINIT1
200     CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,
        IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,
        IBWRTF)
220     CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,
        IBRD,IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,
        IBWRTIA,IBSTA%,IBERR%,IBCNT%)
240 REM *****
260 REM ++++++
280     KEY 9, "EXIT" : ON KEY (9) GOSUB 2580 : KEY (9) ON : REM Interrupt trap.
300 REM ++++++
320 REM ----- Program Graph Data <GRDTA.BAS> -----
340 DIM A$(10100), B$(6000)
360 REM A$(xxxxx) is a matrix used to store signal analyzer graphic data from
        the designated disc file into the computer active memory
380 REM B$(xxxxx) is a matrix used to store the selected graphic portion of
        the signal analyzer disc file to be plotted via the HP plotter
400 CLS : REM Fol box appears on the screen and defines the program function
420 SOUND 940, 10 : SOUND 860, 9
440 PRINT"***** Program <GRDTA.BAS> *****"
460 PRINT"*** This program loads the contents of a designated GPIB disc file ***"
480 PRINT"*** containing integer data into the computer; identifies the file ***"
500 PRINT"*** graphic data section, then plots that disc file graphic data ***"
520 PRINT"*** using the Hewlett Packard plotter. This program can be used ***"
540 PRINT"*** to plot several signal analyzer graphic displays on the same ***"
560 PRINT"*** page, providing direct comparison of different sample results. ***"
580 PRINT"*****"
600 PRINT"*** NOTE: Curves plotted together on the same plotter display ***"
620 PRINT"*** should all have originated from equivalent coordinate scales ***"
640 PRINT"*** when they initially were displayed on the Signal Analyzer. ***"
660 PRINT"*****"
680     ON ERROR GOTO 2540 : REM No existing file error trap.
700     PRINT : INPUT "Type <RETURN> to continue... ", AN$
720     CLS : REM Clear screen.
740 PRINT : FILES "*.dta"
760 PRINT : PRINT "What file name contains your data?"
780 PRINT "File designation must be dta (ie); filename.dta "
800 PRINT "Note: File desig's <EXE>, <BAS>, <BAT> & <COM> will not load."
820 PRINT : INPUT "Filename.dta ...";FILES
840     IF RIGHTS(FILES,3) = "DTA" THEN 1000
860     IF RIGHTS(FILES,3) = "Dta" THEN 1000
880     IF RIGHTS(FILES,3) = "dta" THEN 1000
900     IF RIGHTS(FILES,3) = "dTA" THEN 1000
920     IF RIGHTS(FILES,3) = "dtA" THEN 1000
940     IF RIGHTS(FILES,3) = "dTa" THEN 1000
960     IF RIGHTS(FILES,3) = "DTa" THEN 1000
980     GOTO 400
1000 PRINT:PRINT "Loading the contents of "; FILES; " into the computer... "
1020 PRINT:PRINT "Please wait... "
1040 OPEN "c:\gpiB-pc\" + FILES FOR INPUT AS #1

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1060 FOR I = 1 TO 10000 STEP 4
1080 IF EOF(1) THEN 1240 : REM End of File test.
1100 INPUT#1, A%(I), A%(I+1), A%(I+2), A%(I+3)
1120 IF A%(I) + A%(I+1) + A%(I+2) + A%(I+3) = 0 THEN 1240
1140 PRINT "+";
1160 X = CSRLIN : IF X <= 23 THEN 1200
1180 CLS: LOCATE 4,1 : PRINT "Still loading ";FILES;
1200 NEXT I
1220 REM FE = the number of the last graphic data byte (or ASCII integer)
1240 FE = I : CLOSE #1
1260 CLS: PRINT : PRINT "Disc file ";FILES; " is loaded into active memory... "
1280 PRINT : PRINT "Identifying the start of graphic data ..."
1300 REM The following program section searches through the integer disc file
    and locates the graphic signal analyzer data.
1320 REM The graphic data begins with either (;; PD = 15163 17488) or
    (;P D; = 20539 15172) or (PD ;; = 17488 15163) or (D;;P = 15172 20539).
1340 REM Therefore, we only need check for the integers (17488 = PD) or for
    (15172 = D;) which are common to all four possibilities.
1360 REM The graphic data ends with either (;; PU = 15163 21840) or
    (;P U; = 20539 15189) or (PU ;; = 21840 15163) or (U;;L = 15189 19515).
1380 REM Therefore, we only need check for the integers (21840 = PU) or for
    (15189 = U;) which are common to all four possibilities.
1400 N = -100
1420 FOR J = 1 TO 10000
1440 IF N > 35 THEN 1580
1460 IF A%(J) = 17488 THEN 1500
1480 IF A%(J) <> 15172 THEN 1540
1500 SB% = J : IF N > 35 THEN 1580
1520 N = 0
1540 N = N + 1 : PRINT "!";
1560 NEXT J
1580 REM ** THE STARTING INTEGER FOR GRAPHIC DATA IS NOW SET AS "SB%" **
1600 PRINT : CLS : PRINT "Locating the end of graphic data ..."
1620 FOR K = SB% + 50 TO FE
1640 IF A%(K) = 21840 THEN 1680
1660 IF A%(K) <> 15189 THEN 1700
1680 EB% = K : IF EB% - SB% > 100 THEN 1740
1700 PRINT "#";
1720 NEXT K
1740 REM ** THE ENDING INTEGER FOR GRAPHIC DATA IS NOW SET AS "EB%" **
1760 REM Place the identified graphic data from A%(matrix) into B%(matrix).
1780 PRINT : CLS : PRINT "Storing the identified graphic data in B%(matrix). "
1800 REM The first ten integers of the file are graphic scaling instructions.
1820 FOR KK = 1 TO 10 : B%(KK) = A%(KK) : NEXT KK
1840 REM The following three integers institute a "pen down" instruction.
1860 B%(11) = 15163 : B%(12) = 17488 : B%(13) = 15163
1880 REM The following loop places the actual graphic data into B%(matrix).
1900 FOR L = 14 TO (EB% - SB% + 1)
1920 B%(L) = A%(L + SB% - 14)
1940 PRINT "@";
1960 NEXT L
1980 REM The fol program section plots the graphic data previously identified.
2000 PRINT : CLS : PRINT "Plotting the selected graphic data ... "
2020 CMD1$ = ";;IN;";
2040 CMD2$ = ";;SP;;SP;;SP1;;;PA1100,2100;;;";

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2060  CMD3$ = ";;PU;;PU;;SP;;"
2080  V% = 0 : CNT% = 9000
2100  DEV2$ = "hppltr"
2120  CALL IBFIND (DEV2$, DV%)
2140  CALL IBCMD (DV%, CMD1$)
2160  CALL IBWRT (DV%, CMD2$)
2180  CALL IBTMO (DV%, V%)
2200      PRINT : PRINT "Calling IBWRTI( B%(matrix) )... "
2220      PRINT "The interface board function to plot the data... "
2240  CALL IBWRTI (DV%, B%(0), CNT%)
2260  CALL IBWRT (DV%, CMD3$)
2280  PRINT : PRINT "Starting integer # = ";SB%; " Ending integer # = ";EB%
2300  PRINT : PRINT "Type <KK> to RE-PLOT the same graph."
2320      PRINT "(Reposition graph paper to origin for a re-plot.)"
2340  PRINT : INPUT "Type yes to run the program again..."; ANSS
2360      IF ANSS = "KK" THEN 1980
2380      IF ANSS = "kk" THEN 1980
2400      IF ANSS = "Kk" THEN 1980
2420      IF ANSS = "kK" THEN 1980
2440      IF LEFT$(ANSS,1) = "y" THEN 100
2460      IF LEFT$(ANSS,1) = "Y" THEN 100
2480      RUN "MENU.BAS"
2500  END
2520  REM ***** No existing file error trap *****
2540      IF ERR = 53 THEN PRINT "File not found; try again." : RESUME 420
2560      ON ERROR GOTO 0
2580  REM ***** KEY (9) INTERRUPT SUBROUTINE *****
2600      CLS : LOCATE 4, 1 : BEEP : BEEP
2620      PRINT : PRINT "PROGRAM INTERRUPT... "
2640      PRINT : PRINT "Type <RETURN> to resume this program section."
2660      PRINT : PRINT "Type <KK> to start this program section over."
2680      PRINT : PRINT "Type any other key + <RETURN> to exit to main menu."
2700      PRINT : INPUT ANSS
2720      IF ANSS = "" THEN RETURN
2740      IF ANSS = "KK" THEN 100
2760      IF ANSS = "kk" THEN 100
2780      RUN "menu.bas"

```



```

100 REM ----- Program Screen Data <SCRNDA.BAS> -----
120 CLEAR : REM Zero all variables.
140 DIM A%(10000) : REM Dimension A%(matrix).
160 REM A%(xxxxx) is a matrix used to store signal analyzer graphic data from
    the designated disc file into the computer active memory
180 CLS : REM Fol box appears on the screen and defines the program function
200 SOUND 2010, 10 : SOUND 1980, 9
220 PRINT"***** Program to display disc file <SCRNDA.BAS> *****"
240 PRINT"*** This program loads the contents of a designated GPIB disc file ***"
260 PRINT"*** containing integer data into the computer and then displays ***"
280 PRINT"*** the contents and its decoded ASCII characters for analysis. ***"
300 PRINT"*** Note: File design's can not be <BAT>, <BAS>, <EXE> or <COM>. ***"
320 PRINT"*****"
340 REM ++++++
360 KEY 9, "EXIT" : ON KEY (9) GOSUB 1780 : KEY (9) ON : REM Interrupt trap.
380 REM ++++++
400 ON ERROR GOTO 1680 : REM Set no existing file trap.
420 PRINT : INPUT "Type <RETURN> to continue... ", AN$
440 CLS : REM Clear screen.
460 PRINT : FILES
480 PRINT : INPUT "What file name contains your data";FILES$
500 IF RIGHTS$(FILES$,3) = "exe" THEN 180
520 IF RIGHTS$(FILES$,3) = "EXE" THEN 180
540 IF RIGHTS$(FILES$,3) = "bas" THEN 180
560 IF RIGHTS$(FILES$,3) = "BAS" THEN 180
580 IF RIGHTS$(FILES$,3) = "bat" THEN 180
600 IF RIGHTS$(FILES$,3) = "BAT" THEN 180
620 IF RIGHTS$(FILES$,3) = "com" THEN 180
640 IF RIGHTS$(FILES$,3) = "COM" THEN 180
660 PRINT:PRINT "Loading the contents of "; FILES$; " into the computer... "
680 PRINT:PRINT "Please wait... "
700 OPEN "c:\gpiB-pc\" + FILES$ FOR INPUT AS #1
720 FOR I = 1 TO 10000 STEP 4
740 IF EOF(1) THEN 900
760 INPUT#1, A%(I), A%(I+1), A%(I+2), A%(I+3)
780 IF A%(I) + A%(I+1) + A%(I+2) + A%(I+3) = 0 THEN 900
800 PRINT "+";
820 X = CSRLIN : IF X <= 22 THEN 860
840 CLS: LOCATE 4,1 : PRINT "Still loading ";FILES$;
860 NEXT I
880 REM FE = variable to hold the number of the last graphic data byte
900 FE = I : CLOSE #1
920 ON ERROR GOTO 1740 : REM Set trap for integer overflow.
940 CLS: PRINT "Disc file ";FILES$; " is loaded into active memory ... "
960 REM SB% = starting byte of desired data section EB% = ending byte of
    desired data section
980 SOUND 1900, 8 : SOUND 1880, 6
1000 PRINT:PRINT "Designate the number of the starting byte... ";:INPUT SB%
1020 IF SB% < 1 THEN 980 : REM this line traps invalid byte designations that
    are less than the beginning of the graphic data file.
1040 IF SB% > FE THEN 980 : REM this line traps starting byte designations
    that are greater than the end of the data file.
1060 SOUND 1900, 8 : SOUND 1880, 6
1080 PRINT:PRINT "Designate the number of the ending byte... ";:INPUT EB%
1100 IF EB% > FE THEN 1060 : REM this line traps invalid byte designations

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        that are greater than the end of the data file.
1120 IF EB% < SB% THEN 1060 : REM this line traps invalid ending byte
        designations that are less than the starting byte value.
1140 CLS: PRINT "Your chosen data bytes contain... " : PRINT
1160 REM following line prints output data column headings
1180 PRINT "Byte # Byte # Integer Integer ASCII Characters "
1200 FOR I = SB% TO EB% STEP 2
1220 PRINT SPC(2);I;SPC(2);I+1;SPC(2);
1240 PRINT A%(I);SPC(1);A%(I + 1);SPC(3);
1260 REM the following lines calculate the ASCII Codes equivalent to the
        integers stored in matrix A%(XXXX)
1280 BB = INT(A%(I)/256) : AA = A%(I) - (BB*256)
1300 BB1 = INT(A%(I + 1)/256) : AA1 = A%(I + 1) - (BB1*256)
1320 PRINT CHR$(AA);SPC(1);CHR$(BB);SPC(1);CHR$(AA1);SPC(1);CHR$(BB1)
1340 REM the fol two lines limit screen output to nineteen lines at a
        time SLINE% = the number of <SCREEN LINES> currently displayed
        as output
1360 SLINE% = SLINE% + 1 : IF SLINE% >= 19 THEN 1380 ELSE 1440
1380 SLINE% = 0 : INPUT "Type return for next screen... ";ANSS : CLS
1400 REM the fol line prints output data column headings
1420 PRINT "Byte # Byte # Integer Integer ASCII Characters "
1440 NEXT I
1460 SLINE% = 0 : REM reset screen line number variable
1480 PRINT : PRINT "Type yes to look at other data bytes... " : INPUT ANSS
1500 IF LEFT$(ANSS,1) = "y" THEN 940
1520 IF LEFT$(ANSS,1) = "Y" THEN 940
1540 PRINT : PRINT "Graphic file contained ";FE - 4;" total bytes of data."
1560 PRINT : INPUT "Type yes to examine another disc file... "; ANSS
1580 IF LEFT$(ANSS,1) = "y" THEN 100
1600 IF LEFT$(ANSS,1) = "Y" THEN 100
1620 RUN "MENU.BAS"
1640 END
1660 REM ***** No existing file trap routine *****
1680 IF ERR = 53 THEN PRINT "File not found; try again. " : RESUME 200
1700 ON ERROR GOTO 0
1720 REM ***** Integer overflow trap routine *****
1740 IF ERR = 6 THEN PRINT "INTEGER OVERFLOW GW BASIC (Table A1); TRY AGAIN."
        : RESUME 960
1760 ON ERROR GOTO 0
1780 REM ***** KEY (9) INTERRUPT SUBROUTINE *****
1800 CLS : LOCATE 4, 1 : BEEP : BEEP
1820 PRINT : PRINT "PROGRAM INTERRUPT... "
1840 PRINT : PRINT "Type <RETURN> to resume this program section."
1860 PRINT : PRINT "Type <KK> to start this program section over."
1880 PRINT : PRINT "Type any other key + <RETURN> to exit to main menu."
1900 PRINT : INPUT ANSS
1920 IF ANSS = "" THEN RETURN
1940 IF ANSS = "KK" THEN 100
1960 IF ANSS = "kk" THEN 100
1980 RUN "menu.bas"

```

```

100 REM ***** Program <ITERPLOT.BAS> *****
120 CLEAR ,59504!:REM BASIC Declarations
140 IBINIT1 = 59504!
160 IBINIT2 = IBINIT1 + 3:REM Lines 120 through 220 MUST be included
180 BLOAD "bib.m",IBINIT1
200 CALL IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,
IBRSC,IBSRE,IBRSV,IBPAD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,
IBWRTF)
220 CALL IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,
IBRD,IBRDA,IBSTOP,IBRPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,
IBWRTIA,IBSTA%,IBERR%,IBCNT%)
240 REM ***** end of gpib-pc interface board header *****
260 REM ++++++
280 KEY 9, "EXIT" : ON KEY (9) GOSUB 2140 : KEY (9) ON : REM Interrupt trap.
300 REM ++++++
320 DIM A$(10000), B$(10000) : REM Dimension A$(matrix) & B$(matrix).
340 ON ERROR GOTO 2020 : REM Set no existing file error trap.
360 SOUND 900,10 : SOUND 800,8 : CLS : REM Beep & clear screen.
380 PRINT "***** Program <ITERPLOT.BAS> *****"
400 PRINT "*** Program to selectively plot data from an operator desig'd ***"
420 PRINT "*** disc file. This program runs the HP-plotter to draw a ***"
440 PRINT "*** graph using designated portions of graphic data from a ***"
460 PRINT "*** disc file that was originally obtained from the Scientific ***"
480 PRINT "*** Atlanta signal analyzer screen display by <FPLOT.BAS>. ***"
500 PRINT "*****"
520 PRINT : INPUT "Type <RETURN> to continue... ",ANS$
540 CLS
560 PRINT : FILES "*.dta"
580 PRINT : PRINT "What disc file do you wish to plot? "
600 PRINT "Note: File designation must be dta (i.e.) filename.dta "
620 PRINT : INPUT "What filename.dta ";FILES$
640 IF RIGHTS$(FILES$,3) = "dta" THEN 760
660 IF RIGHTS$(FILES$,3) = "Dta" THEN 760
680 IF RIGHTS$(FILES$,3) = "DTa" THEN 760
700 IF RIGHTS$(FILES$,3) = "dTa" THEN 760
720 IF RIGHTS$(FILES$,3) = "dTA" THEN 760
740 IF RIGHTS$(FILES$,3) <> "DTA" THEN 360
760 PRINT : PRINT "Loading ";FILES$;" ... Please wait... "
780 CNT% = 12000
800 OPEN "c:\gpib-pc\" + FILES$ FOR INPUT AS #1
820 FOR I = 1 TO 10000 STEP 4
840 IF EOF(1) THEN 980
860 INPUT#1, A$(I), A$(I+1), A$(I+2), A$(I+3)
880 IF A$(I) + A$(I+1) + A$(I+2) + A$(I+3) = 0 THEN 980
900 PRINT "+";
920 X = CSRLIN : IF X < 22 THEN 960
940 CLS : LOCATE 4,1 : PRINT "Still loading ";FILES$
960 NEXT I
980 EF% = I : CLOSE #1 : REM Variable EF% is the End of Disc File index.
1000 CLS : PRINT "Note: The first several data bytes from the disc file
contain graphic " : PRINT "scale and pen positioning instructions.
Thus, you need at least the first " : PRINT "ten bytes to produce
a readable graphic segment on the HP plotter."
1020 PRINT : PRINT "Designate the number of bytes you wish to use from the "
: PRINT " beginning of the disc file (scale, border, etc.) " ;

```

```

: INPUT BF%
1040 IF BF% > EF% THEN 1020 : REM trap for byte number designation that is
      greater than the length of the file
1060 IF BF% < 0 THEN 1020 : REM trap for byte designation that is
      less than zero
1080 PRINT : INPUT "Designate the starting byte for the graphic data... "; SB%
1100 IF SB% < BF% THEN 1080 : REM trap for starting byte less than BF%
1120 IF SB% < 0 THEN 1080 : REM trap for starting byte less than zero
1140 IF SB% > EF% THEN 1080 : REM trap for starting byte greater than EF%
1160 PRINT : INPUT "Designate the ending byte for the graphic data... "; EB%
1180 IF EB% < SB% THEN 1160 : REM trap for ending byte value less than
      starting byte value
1200 IF EB% < 0 THEN 1160 : REM trap for ending byte value less than zero
1220 IF EB% > EF% THEN 1160 : REM trap for ending byte value greater than
      the disc file length
1240 PRINT:PRINT "Rearranging original graphic data as requested... "
1260 FOR J = 1 TO BF% : B%(J) = A%(J) : NEXT J
1280 B%(BF% + 1) = 17488 : B%(BF% + 2) = 11514 : B%(BF% + 3) = 15383
      : B%(BF% + 4) = 15163 : REM initiate pen position to P1
      (HP-program manual, pg. 2-2)
1300 N = 0 : REM set index for A%(matrix) starting byte
1320 REM Set B%(matrix) equal to chosen graphic data portion of A%(matrix)
1340 FOR K = BF% + 5 TO EB% - (SB% - BF% - 1)
1360 B%(K) = A%(SB% + N)
1380 N = N + 1
1400 NEXT K
1420 REM Program section to address & activate the hp-plotter.
1440 CMD1$ = ";;;ATN;;;";
1460 CMD2$ = ";;;IN;;;";
1480 CMD3$ = ";;;PA1100,2100;;;";
1500 DEV$ = "HPPLTR"
1520 CALL IBFIND (DEV$, DV%)
1540 CALL IBCMD (DV%, CMD1$)
1560 CALL IBCMD (DV%, CMD2$)
1580 CALL IBWRT (DV%, CMD3$)
1600 REM program section to send selected data to plotter
1620 PRINT : PRINT "Plotting the rearranged data... "
1640 V% = 0 : CMD4$ = ";;;PU;;;PU;;;SP;;;";
1660 CALL IBTMO (DV%, V%)
1680 CALL IBWRTI (DV%, B%(0), CNT%)
1700 CALL IBWRT (DV%, CMD4$)
1720 PRINT "plotter status... "; IBSTA%
1740 PRINT : PRINT "Type K + <RETURN> to plot the same graph. "
1760 PRINT : PRINT "Type I + <RETURN> to select and plot different portions"
1780 PRINT " of the same graph. "
1800 PRINT : PRINT "Type <YES> + <RETURN> to select another disc file."
1820 PRINT : INPUT "Type <RETURN> to exit to main menu. ",ANSS
1840 IF ANSS = "K" THEN 1420
1860 IF ANSS = "I" THEN 2060
1880 IF ANSS = "k" THEN 1420
1900 IF ANSS = "i" THEN 2060
1920 IF LEFT$(ANSS,1) = "y" THEN 100
1940 IF LEFT$(ANSS,1) = "Y" THEN 100
1960 RUN "MENU.BAS"
1980 END

```

```

2000 REM ***** No existing file error trap routine *****
2020     IF ERR = 53 THEN PRINT "File not found; try again. " : RESUME 380
2040     ON ERROR GOTO 0
2060 REM ***** Routine to zero B%(matrix) in prep for reuse *****
2080     ERASE B% : REM Erase B%(matrix) to clear previous chosen elements.
2100     DIM B%(10000) : REM Redimension B%(matrix) to store next set elements.
2120     GOTO 1000
2140 REM ***** KEY (9) INTERRUPT SUBROUTINE *****
2160     CLS : LOCATE 4, 1 : BEEP : BEEP
2180     PRINT : PRINT "PROGRAM INTERRUPT... "
2200     PRINT : PRINT "Type <RETURN> to resume this program section."
2220     PRINT : PRINT "Type <KK> to start this program section over."
2240     PRINT : PRINT "Type any other key + <RETURN> to exit to main menu."
2260     PRINT : INPUT ANSS
2280     IF ANSS = "" THEN RETURN
2300     IF ANSS = "KK" THEN 100
2320     IF ANSS = "kk" THEN 100
2340     RUN "menu.bas"

```



```

100 REM *****
120 CLEAR : REM Clear memory for start or restart.
140 REM ----- Program Graph Data <DAMPCALC.BAS> -----
160 DIM A$(10000), B$(4000)
180 REM A$(xxxxx) is a matrix used to store signal analyzer graphic data in
      integer form from the designated disc file
200 REM A$(xxxxx) is RE-USED to store the decoded analyzer XY-coordinates
220 REM B$(xxxxx) is a matrix to store the identified graphic portion of
      the analyzer integer file required for damping calculations
240 REM C$(xxxxx) is a matrix to store the decoded ASCII graphic data
      deciphered from the orig analyzer integer disc file
260 REM ++++++
280 KEY 9, "EXIT" : ON KEY (9) GOSUB 4920 : KEY (9) ON : REM Interrupt trap.
300 REM ++++++
320 CLS : REM Fol box appears on the screen and defines the program function
340 SOUND 900, 10 : SOUND 840, 9
360 PRINT"***** Program <DAMPCALC.BAS> *****"
380 PRINT"*** This program loads the integer contents of a designated GPIB ***"
400 PRINT"*** disc file into the computer; identifies the file graphic data ***"
420 PRINT"*** section; then calculates the Specific Damping Capacity (SDC) ***"
440 PRINT"*** and the Damping Coefficient (DC) for the selected data file. ***"
460 PRINT"*** SDC & DC are calculated in absolute HP-plotter coord terms ***"
480 PRINT"*** and may vary some from Signal Analyzer values. This program ***"
500 PRINT"*** will also store the S/A graphic XY-coordinates as absolute ***"
520 PRINT"*** HP-plotter integer magnitudes, if desired. (The program ***"
540 PRINT"*** <GRAPHXYC.BAS> can display stored disc file graphic data on ***"
560 PRINT"*** the microcomputer screen. (Selection #10 from the Main Menu)) ***"
580 PRINT"*****"
600 PRINT"*** Note: This program will not function correctly with signal ***"
620 PRINT"*** analyzer dual screen traces that are stored to disc. GPIB ***"
640 PRINT"*** disc data files must be single traces of amplitude vs freq. ***"
660 PRINT"*****"
680 ON ERROR GOTO 4880 : REM No existing disc file error trap.
700 PRINT : INPUT "Type <RETURN> to continue... ", ANSS
720 CLS : REM Clear screen.
740 PRINT : FILES "*.dta"
760 PRINT : PRINT "What file name contains your data?"
780 PRINT "File designation must be dta (ie); filename.dta "
800 PRINT : INPUT "Filename.dta ...";FILES
820 IF RIGHTS(FILES,3) = "DTA" THEN 960
840 IF RIGHTS(FILES,3) = "DTa" THEN 960
860 IF RIGHTS(FILES,3) = "Dta" THEN 960
880 IF RIGHTS(FILES,3) = "dTA" THEN 960
900 IF RIGHTS(FILES,3) = "dtA" THEN 960
920 IF RIGHTS(FILES,3) <> "dta" THEN 320
940 REM *****
960 CLS : PRINT "Loading the contents of "; FILES; " into the computer... "
980 PRINT : PRINT "Disc file contents are ... Please wait... "
1000 OPEN "c:\gpib-pc\" + FILES FOR INPUT AS #1
1020 FOR I = 1 TO 10000 STEP 4
1040 IF EOF(1) THEN 1200
1060 INPUT#1, A$(I), A$(I+1), A$(I+2), A$(I+3)
1080 IF A$(I) + A$(I+1) + A$(I+2) = 0 THEN 1200
1100 PRINT A$(I),A$(I+1),A$(I+2),A$(I+3),;
1120 X = CSRLIN : IF X <= 23 THEN 1160

```



```

1140      CLS: LOCATE 4,1 : PRINT "Loading contents of ";FILES
1160      NEXT I
1180 REM FE = the index <File End> of the last graphic data byte
                                (or ASCII integer)

1200      FE = I : CLOSE #1
1220 CLS: PRINT : PRINT "Disc file ";FILES; " is loaded into active memor ..."
1240 REM ***** ID GRAPHIC DATA START *****
1260 PRINT : PRINT "Identifying the start of graphic data ..."
1280 REM The following program section searches through the integer disc file
      and locates the graphic signal analyzer data.
1300 REM The graphic data begins with either (;; PD = 15163 17488) or
      (P D; = 20539 15172) or {PD ;; = 17488 15163} or {D;;P = 15172 20539}.
1320 REM Therefore, we only need check for the integers {17488 = PD} or for
      {15172 = D;} which are common to all four possibilities.
1340 REM The graphic data ends with either (;; PU = 15163 21840) or
      (P U; = 20539 15189) or {PU ;; = 21840 15163} or {U;;L = 15189 19515}.
1360 REM Therefore, we only need check for the integers {21840 = PU} or for
      {15189 = U;} which are common to all four possibilities.
1380      N = -100 : REM Set N < 0, "N" is a test index for next loop.
1400 REM *****
1420 REM Fol loop finds starting index (SB%) for the graphic data.
1440      FOR J = 1 TO 10000
1460          IF A%(J) = 17488 THEN 1500
1480          IF A%(J) <> 15172 THEN 1540
1500              SB% = J
1520              N = 0
1540          IF N > 35 THEN 1600 : REM Identifies a graphic data section > 35
              characters long.
1560              N = N + 1 : PRINT "!";
1580      NEXT J
1600 REM ** THE STARTING INTEGER FOR GRAPHIC DATA IS NOW SET AS "SB%" **
1620 REM ***** ID END OF GRAPHIC DATA *****
1640 PRINT : CLS : PRINT "Locating the end of graphic data ..."
1660 REM Fol loop finds ending index (EB%) for the graphic data.
1680      FOR K = SB% + 50 TO FE
1700          IF A%(K) = 21840 THEN 1760
1720          IF A%(K) <> 15189 THEN 1780
1740          REM {EB% - SB% > 100} identifies a graphic section > 100
              characters long.
1760              EB% = K : IF EB% - SB% > 100 THEN 1820
1780          PRINT "#";
1800      NEXT K
1820 REM ** THE ENDING INTEGER FOR GRAPHIC DATA IS NOW SET AS "EB%" **
1840 PRINT : PRINT "Starting integer # = ";SB%; " Ending integer # = ";EB%
1860      FOR KK = 1 TO 2000: NEXT KK : REM A delay line to display SB% & EB%.
1880 REM ***** STORE GRAPHIC DATA IN B%(matrix) *****
1900 REM Place the identified graphic data from A%(matrix) into B%(matrix).
1920 PRINT : CLS : PRINT "Storing the identified integer data in B%(matrix)."
1940 REM The following loop places the actual graphic data into B%(matrix).
1960      FOR L = 1 TO (EB% - SB% + 1)
1980          B%(L) = A%(L + SB% - 1)
2000          PRINT B%(L);SPC(1);
2020      NEXT L
2040 REM ***** ZERO A%(matrix) & DIM C$(matrix) *****
2060      ERASE A% : REM Erasing A%(matrix) to conserve memory space.

```

```

2080 DIM C$(8000) : REM Dimension C$(matrix) for ASCII data.
2100 REM -----
2120 REM ***** Program section to decode & display graphic data *****
2140 PRINT : PRINT : PRINT "Decoding the integer graphic data."
2160 PRINT : PRINT "Storing the decoded ASCII graphic data in C$(matrix)."

```

```

3020      XS = XS + CS(J)
3040      J = J + 1
3060      IF ASC(CS(J)) <> 44 THEN 3020
3080      REM Transfer decoded X coord to A%(matrix).
3100      A%(N) = VAL(XS) : J = J + 1
3120      YS = YS + CS(J) : J = J + 1
3140      IF ASC(CS(J)) <> 59 THEN 3120
3160      REM Transfer decoded Y coord to A%(matrix INDEX + 3300).
3180      A%(N + 3300) = VAL(YS) : N = N + 1
3200      XS = "" : YS = "" : REM Reset temporary string values to null.
3220      JK = JK + 1 : J = J + 1
3240      IF 2*(EB%-SB%) - J > 0 THEN 2960 : REM End coordinate loop.
3260 REM ***** Start loop to store XY-coordinates on DISC *****
3280      CLS : LOCATE 4,1 : SOUND 800,10 : SOUND 760,8
3300      PRINT "Graphic XY-coordinates for ";FILES;" have been determined. "
3320      PRINT : INPUT "Type <YES> to store XY-coordinates... ",ANS$
3340      IF LEFT$(ANS$,1) = "Y" THEN 3380
3360      IF LEFT$(ANS$,1) <> "y" THEN 3620
3380      PRINT : PRINT "What XY-coord filename?"
3400      PRINT:PRINT "File designations must be XYC (ie) FILENAME.XYC "
3420      PRINT : INPUT "Filename.XYC ... ";XYFILES
3440      IF RIGHT$(XYFILES,3) = "XYC" THEN 3480
3460      IF RIGHT$(XYFILES,3) <> "xyz" THEN 3380
3480      PRINT : PRINT "Storing your XY-graphic coordinates... "
3500      OPEN "C:\GPIB-PC\" + XYFILES FOR OUTPUT AS #2
3520      FOR J = 1 TO N
3540          PRINT #2, USING "#####"; A%(J); A%(J + 3300);
3560      NEXT J
3580      PRINT #2, USING "#####"; 0;0;0;0
3600      CLOSE #2
3620 REM ***** Find XMAX & YMAX & Y3DB DOWN *****
3640 REM ++++++ NULL CS(matrix) ++++++
3660      ERASE CS : REM Erasing CS(matrix) to conserve memory space.
3680 REM .....
3700 PRINT : PRINT : PRINT "Identifying XMAX and YMAX plus Y3DB-DOWN."
3720 PRINT : PRINT "Graphic numeric X & Y coordinates are ..."
3740      XMAX% = 0 : YMAX% = 0 : REM Set maximum initial XY coords to zero.
3760      FOR JJ = 1 TO N-1
3780          PRINT "      X(";JJ;") = ";A%(JJ);SPC(4);
3800          PRINT "      Y(";JJ;") = ";A%(JJ + 3300)
3820          IF A%(JJ + 3300) < YMAX% THEN 3860
3840              YMAX% = A%(JJ + 3300) : XMAX% = A%(JJ) : INDEX = JJ
3860      NEXT JJ
3880      YBTM% = (A%(3300 + N - 2) + A%(3302))/2!
3900      Y3DBD = .7071067 * (YMAX% - YBTM%) + YBTM%
3920 PRINT : PRINT "Graphic file contained ";FE - 3;" total data integers."
3940 PRINT : PRINT "XMAX = ";XMAX%;" YMAX = ";YMAX%
3960 PRINT "Y(3db down) = ";Y3DBD
3980 REM ***** ID W1 and W2 *****
4000 PRINT : PRINT "Identifying W1 and W2 at Y(3db down)... "
4020      TOL = 2.5 : REM Set comparison tolerance to two and one-half.
4040 REM Start loop to locate/identify horiz axis values (freq) X1 and X2
      corres to Y(3db down) values to the left & right of peak db-amplitude.
4060      TL = -100! : REM Set test index for next loop to zero.
4080      X1 = 0! : X2 = 0! : REM Set initial 3db-down X-coords to zero.

```



```

4100     FOR KK = 1 TO N-1 : REM Start loop to identify X1 and X2.
4120         PRINT "$";
4140         IF ABS(A%(KK + 3300) - Y3DBD) > TOL THEN 4280
            : REM Check tolerance.
4160         REM Skip setting X1 value if previously found.
4180         IF TL > 0! THEN 4260
4200         X1 = A%(KK) : TL = 10! : REM Set X1 and TL
4220         REM Move to far side of curve amplitude maximum.
4240         KK = INDEX : GOTO 4280
4260         X2 = A%(KK) : GOTO 4320 : REM Set X2 and exit loop.
4280     NEXT KK
4300 REM ***** SDC Correction Factor Section *****
4320     PRINT : PRINT
4340     INPUT "What SDC/DC correction factor";CF$
4360     CF = VAL(CF$)
4380     IF CF = 0! THEN 4320
4400     PRINT : PRINT
4420 REM ***** Calculate SDC & DC *****
4440 REM Calculate Specific Damping Capacity (SDC) & Damping Coefficient (DC)
4460     SDC = 200!*3.1415926*((X2 - X1)/XMAX%)
4480     SDC = SDC/CF
4500     DC = (X2 - X1)/(2! * XMAX%)
4520     DC = DC/CF
4540     PRINT : PRINT "*****"
4560     PRINT : PRINT "  VALUES FOR ";FILES;SPC(3);"YMAX(Abs) = ";YMAX%
4580     PRINT : PRINT "    SDC = "; SDC; " % ";SPC(3);"X(0) = ";A%(1)
4600     PRINT : PRINT "    DC  = "; DC ;SPC(3); "XMAX(Abs) = ";A%(N-2)
4620     PRINT : PRINT "-----"
4640     PRINT : PRINT "  SDC/DC CORRECTION FACTOR OF ";CF
4660     PRINT : PRINT "*****"
4680     PRINT:INPUT "Type any key + <RETURN> to ReEnter the SDC/DC factor ",ANSS
4700     IF ANSS <> "" THEN 4320
4720     PRINT : PRINT
4740 REM *****
4760     PRINT : INPUT "Type yes to examine another disc file... "; ANSS
4780     IF LEFT$(ANSS,1) = "y" THEN 100
4800     IF LEFT$(ANSS,1) = "Y" THEN 100
4820     RUN "MENU.BAS"
4840     END
4860 REM ***** No existing disc file error trap *****
4880     IF ERR = 53 THEN PRINT "File not found; try again. " : RESUME 340
4900     ON ERROR GOTO 0
4920 REM ***** KEY (9) INTERRUPT SUBROUTINE *****
4940     CLS : LOCATE 4, 1 : BEEP : BEEP
4960     PRINT : PRINT "PROGRAM INTERRUPT... "
4980     PRINT : PRINT "Type <RETURN> to resume this program section."
5000     PRINT : PRINT "Type <KK> to start this program section over."
5020     PRINT : PRINT "Type any other key + <RETURN> to exit to main menu."
5040     PRINT : INPUT ANSS
5060     IF ANSS = "" THEN RETURN
5080     IF ANSS = "KK" THEN 100
5100     IF ANSS = "kk" THEN 100
5120     RUN "menu.bas"

```

```

100 REM ***** GPIB-PC PROGRAM HEADER *****
120 CLEAR : REM Clear memory for start or restart.
140 REM ----- Program Graph Data <GRAPHXYC.BAS> -----
160 DIM X%(1000), Y%(1000), YY%(1000)
180 REM X%(xxxxx) is a matrix used to store X-coordinates from the
      designated disc file in the computer active memory
200 REM Y%(xxxxx) is a matrix used to store Y-coordinates from the
      designated disc file in the computer active memory
220 REM YY%(xxxxx) is a matrix holding "smoothed" Y-coord values used for
240 REM calculation of SDC & DC. These coords are displayed on the computer
260 REM screen for verification that smoothed curve fit is satisfactory.
280 REM Note that X-coord values remain unchanged in both index and value.
300 REM *****
320 REM ++++++
340 KEY 9, "EXIT" : ON KEY(9) GOSUB 4200 : KEY(9) ON : REM Interrupt trap.
360 REM ++++++
380 CLS : REM Fol box appears on the screen and defines the program function
400 SOUND 900, 10 : SOUND 840, 9
420 PRINT"***** Program <GRAPHXYC.BAS> *****"
440 PRINT"** This program loads the XY-coordinate contents of a designated **"
460 PRINT"** disc file into the computer, then displays those coordinates **"
480 PRINT"** graphically on the computer screen. A second curve is also **"
500 PRINT"** displayed that is a SMOOTHED version of the disc file graph. **"
520 PRINT"** The SMOOTHED version is used for SDC & DC calculations, so **"
540 PRINT"** its visual FIT to the disc file graphic data is displayed on **"
560 PRINT"** the computer screen for comparison. XY-coord disc files used **"
580 PRINT"** by this program must have been produced by <DAMPCALC.BAS>. **"
600 PRINT"*****"
620 PRINT"** Note: Disc files for this program must have file designations **"
640 PRINT"** of <XYC> (ie) FILENAME.XYC Other file types will not **"
660 PRINT"** load correctly. **"
680 PRINT"*****"
700 ON ERROR GOTO 4160 : REM No existing disc file error trap.
720 PRINT : INPUT "Type <RETURN> to continue... ",ANS$
740 CLS : FILES "*.xyc"
760 PRINT : PRINT "What file name contains your XY-coord data?"
780 PRINT "File designation must be xyc (ie); filename.xyc "
800 PRINT : INPUT "Filename.xyc ...";FILES
820 IF RIGHTS(FILES,3) = "XYC" THEN 880
840 IF RIGHTS(FILES,3) <> "xyc" THEN 380
860 REM ***** DISC FILE LOADING SECTION *****
880 CLS : PRINT "Loading the contents of "; FILES; " into the computer... "
900 PRINT : PRINT "Disc file contents are ... Please wait... "
920 OPEN "c:\gpiib-pc\" + FILES FOR INPUT AS #1
940 FOR I = 1 TO 6000
960 IF EOF(1) THEN 1120
980 INPUT#1, X%(I), Y%(I)
1000 IF X%(I) + Y%(I) = 0 THEN 1120
1020 PRINT X%(I), Y%(I);
1040 X = CSRLIN : IF X <= 23 THEN 1080
1060 CLS: LOCATE 4,1 : PRINT "Loading contents of ";FILES
1080 NEXT I
1100 REM FE = the index <File End> of the last graphic coordinate.
1120 FE = I : CLOSE #1
1140 CLS:PRINT : PRINT "Disc file ";FILES; " is loaded into active memory ..."

```



```

1160 REM *****
1180 REM ***** SECTION TO LOCATE XMAX% & YMAX% & THEIR INDEX *****
1200 PRINT : PRINT : PRINT "Identifying XMAX and YMAX."
1220 PRINT : PRINT "Graphic numeric X & Y coordinates are ..."
1240     XMAX% = 0 : YMAX% = 0 : REM Set maximum initial XY coords to zero.
1260     FOR JJ = 1 TO FE-1
1280         PRINT " ";
1300         PRINT "X(";JJ;") = ";X%(JJ);SPC(4);
1320         PRINT "Y(";JJ;") = ";Y%(JJ)
1340         IF Y%(JJ) < YMAX% THEN 1400
1360             YMAX% = Y%(JJ) : XMAX% = X%(JJ)
1380             INDEX = JJ
1400     NEXT JJ
1420 REM ***** CURVE SMOOTHING SECTION *****
1440 REM The smoothing routine calculates the average Y-coord increase over
1460 REM the left half of the maxima curve (LYI == left Y-coord increment)
1480 REM and the right half of the maxima curve (RYI == right Y-coord incr.)
1500 REM Then the program adds proportionate amounts of the LYI to the Y-coord
1520 REM value at the left end (X minimum, Y minimum -- left) of the curve,
1540 REM continuing to the maximum Y-coord value (marked by INDEX). The
1560 REM right half of the curve is determined in a similar manner. However,
1580 REM the RYI is NEGATIVE, so it is subtracted in proportionate amounts
1600 REM from the curve maximum Y-coord value and preceeding to the right
1620 REM end of the curve (X minimum, Y minimum -- right). Note that the
1640 REM X-coord values are NOT changed in index nor magnitude.
1660 PRINT : PRINT "Smoothing the curve for ";FILES$;" ..... "
1680     FOR KK = 1 TO INDEX
1700         REM LYI == left half of graph Y-coords average increment
1720         LYI = LYI + (Y%(KK+1) - Y%(KK))
1740     NEXT KK
1760     LYI = LYI/INDEX : REM LYI now set as equal Y-coord increment
                        per coord
1780     FOR MM = INDEX TO FE-2
1800         REM RYI == right half of graph Y-coords average increment
1820         RYI = RYI + (Y%(MM+1) - Y%(MM))
1840     NEXT MM
1860     RYI = RYI/(FE-1-INDEX) : REM RYI now set as equal Y-coord increment
1880     FOR NN = 1 TO INDEX
1900         REM A smoothing factor of 1.05 was used for the left half of the
1920         REM curve. This factor can be changed by the programmer to suit
1940         REM his curve fitting preferences.
1960         REM Smooth left half of graph Y-coords (smoothing factor 1.05).
1980         YY%(NN) = Y%(1) + ((NN-1) * LYI) * 1.05 * (Y%(NN)/YMAX%)^1.5
2000     NEXT NN
2020     XXX = 1!
2040     FOR OO = INDEX+1 TO FE-1
2060         REM A smoothing factor of 1.20 was used for the right half of the
2080         REM curve. This factor can be changed by the programmer to suit
2100         REM his curve fitting preferences.
2120         REM Smooth right half of graph Y-coords (smoothing factor 1.2).
2140         YY%(OO) = Y%(INDEX) + (XXX * RYI) * 1.2 * (Y%(FE-1)/Y%(OO))^1.5
2160         XXX = XXX + 1!
2180     NEXT OO
2200 REM ***** Calculate Y3db down (Half-power Y-coord) *****
2220     YBTM% = (Y%(2) + Y%(FE-2))/2!

```

```

2240          Y3DBD = .7071067 * (YMAX% - YBTM%) + YBTM%
2260 PRINT : PRINT "Graphic file contained ";FE - 1;" total XY-coordinates."
2280 PRINT: PRINT "XMAX = ";XMAX%;" YMAX = ";YMAX%;"
          INDEX OF X&Y MAX = ";INDEX
2300 PRINT "Y(3db down) =";Y3DBD
2320 REM ***** SECTION TO IDENTIFY W1 & W2 *****
2340 PRINT : PRINT "Identifying W1 and W2 at Y(3db down)... "
2360 TOL = 2.5 : REM Set tolerance for selection of W1 and W2.
2380 REM Start loops to locate/identify horiz axis values (freq) W1 and W2
      corres to Y(3db down) values to the left & right of peak
      db-amplitude.
2400 W1 = 0! : W2 = 0! : REM Set W1 & W2 initially to zero.
2420 REM Start loop for finding W1.
2440 FOR KK = INDEX TO 1 STEP -1
2460 PRINT "S";
2480 IF ABS(YY%(KK) - Y3DBD) > TOL THEN 2540 : REM Identity tolerance.
2500 W1 = X%(KK) : REM Set W1 to identified value.
2520 PRINT : PRINT : PRINT "W1 FOUND ..." : GOTO 2580
2540 NEXT KK
2560 REM Start loop for finding W2.
2580 FOR KL = INDEX TO FE - 1
2600 PRINT "S";
2620 IF ABS(YY%(KL) - Y3DBD) > TOL THEN 2680 : REM Identity tolerance.
2640 W2 = X%(KL) : REM Set W2 to identified value.
2660 PRINT : PRINT : PRINT "W2 FOUND ..." : GOTO 2700
2680 NEXT KL
2700 PRINT : PRINT "W1 = ";W1;SPC(2);"W2 = ";W2 : PRINT
2720 REM ***** SECTION TO CALCULATE SDC & LD *****
2740 PRINT : INPUT "What SDC/DC correction factor";CF$
2760 CF = VAL(CF$)
2780 IF CF = 0! THEN 2740
2800 REM Calculate Specific Damping Capacity (SDC) & Damping Coefficient (DC)
2820 SDC = 200!*3.1415926#*((W2 - W1)/XMAX%)
2840 SDC = SDC/CF
2860 DC = (W2 - W1)/(2! * XMAX%)
2880 DC = DC/CF
2900 CLS : PRINT : PRINT : REM Clear screen and position results display.
2920 PRINT : PRINT "*****"
2940 PRINT : PRINT "      RESULTS FOR "; FILES
2960 PRINT : PRINT "      SDC = "; SDC; " Percent "
2980 PRINT : PRINT "      DC = "; DC
3000 PRINT : PRINT "      PLOTTER COORD YMAX(Abs) = ";YMAX%
3020 PRINT : PRINT "      X(0) = "; X%(1);SPC(2);"X(MAX) = ";X%(FE-2)
3040 PRINT : PRINT "      SDC/DC CORRECTION FACTOR IS ";CF
3060 PRINT : PRINT "*****"
3080 PRINT : INPUT "Type any key + <RETURN> to ReEnter the SDC/DC factor ",ANSS$
3100 IF ANSS$ <> "" THEN 2720
3120 PRINT : PRINT
3140 INPUT "Type <RETURN> for graph of file data.",ANSS$
3160 REM ***** SECTION TO PLOT GRAPHICS *****
3180 REM XFCTR & YFCTR permit moving the screen trace about the screen X-Y
      coordinate field. A positive XFCTR moves trace to the right.
      A positive YFCTR moves the trace down.
3200 XFCTR = 0! : YFCTR = 0!
3220 CLS : SCREEN 2

```

```

3240 LINE (0,0) - (639,199),1,B
3260 PSET (0, 199), 1
3280 FOR MM = 1 TO FE-1
3300 X1 = (X%(MM) * 638!)/X%(FE-1) + XFCTR
3320 Y1 = 198! - (Y%(MM) * 198!)/YMAX% + YFCTR
3340 LINE - (X1, Y1)
3360 NEXT MM
3380 PSET (0, 199), 1
3400 FOR MN = 1 TO FE-1
3420 X1 = (X%(MN) * 638!)/X%(FE-1) + XFCTR
3440 Y1 = 198! - (Y%(MN) * 198!)/YMAX% + YFCTR
3460 LINE - (X1, Y1)
3480 NEXT MN
3500 REM ***** Mark W1 and W2 Positions with Vertical Lines *****
3520 LINE (W1*638!/X%(FE-1)+XFCTR, YMAX%/10!) - (W1*638!/X%(FE-1)+XFCTR, 198)
3540 LINE (W1*636!/X%(FE-1)+XFCTR, YMAX%/10!) - (W1*636!/X%(FE-1)+XFCTR, 198)
3560 LINE (W1*640!/X%(FE-1)+XFCTR, YMAX%/10!) - (W1*640!/X%(FE-1)+XFCTR, 198)
3580 LINE (W2*638!/X%(FE-1)+XFCTR, YMAX%/10!) - (W2*638!/X%(FE-1)+XFCTR, 198)
3600 LINE (W2*636!/X%(FE-1)+XFCTR, YMAX%/10!) - (W2*636!/X%(FE-1)+XFCTR, 198)
3620 LINE (W2*640!/X%(FE-1)+XFCTR, YMAX%/10!) - (W2*640!/X%(FE-1)+XFCTR, 198)
3640 REM ***** Plot Grid Lines *****
3660 LINE (0,20) - (638,20) : LINE (0,40) - (638,40)
3680 LINE (0,60) - (638,60) : LINE (0,80) - (638,80)
3700 LINE (0,100) - (638,100) : LINE (0,120) - (638,120)
3720 LINE (0,140) - (638,140) : LINE (0,160) - (638,160)
3740 LINE (0,180) - (638,180)
3760 LINE (64,0) - (64,198) : LINE (128,0) - (128,198)
3780 LINE (192,0) - (192,198) : LINE (256,0) - (256,198)
3800 LINE (320,0) - (320,198) : LINE (384,0) - (384,198)
3820 LINE (448,0) - (448,198) : LINE (512,0) - (512,198)
3840 LINE (576,0) - (576,198)
3860 REM -----
3880 PRINT "SCREEN TRACE OF ";FILES$;" SIGNAL ANALYZER DISC FILE"
3900 PRINT "A positive XFCTR moves trace to the right. A positive YFCTR
      moves "
3920 PRINT "screen trace down. <XFCTR + YFCTR = 0> exits the graph mode ... "
3940 INPUT "WHAT XFCTR = ";XFCTR
3960 INPUT "WHAT YFCTR = ";YFCTR
3980 IF XFCTR + YFCTR <> 0! THEN 3220
4000 REM ***** PROGRAM ENDING *****
4020 SCREEN 0 : REM Set the text screen.
4040 PRINT : INPUT "Type yes to examine another disc file... "; ANSS
4060 IF LEFT$(ANSS,1) = "y" THEN 100
4080 IF LEFT$(ANSS,1) = "Y" THEN 100
4100 RUN "MENU.BAS"
4120 END
4140 REM ***** No existing disc file error trap *****
4160 IF ERR = 53 THEN PRINT "File not found; try again. " : RESUME 400
4180 ON ERROR GOTO 0
4200 REM ***** INTERRUPT TRAP SUBROUTINE *****
4220 BEEP : BEEP : CLS
4240 LOCATE 4,1 : PRINT "PROGRAM INTERRUPTED..."
4260 PRINT : PRINT "TYPE <RETURN> TO RESUME PROGRAM EXECUTION."
4280 PRINT : PRINT "TYPE KK TO SELECT ANOTHER DATA FILE."
4300 PRINT : PRINT "TYPE ANY OTHER KEY + <RETURN> TO EXIT TO MAIN MENU."

```

```
4320      INPUT ; ANSS
4340      IF ANSS = "" THEN RETURN
4360      IF ANSS = "KK" THEN 4000
4380      IF ANSS = "kk" THEN 4000
4400      RUN "MENU.BAS"
```

APPENDIX F

FIGURES

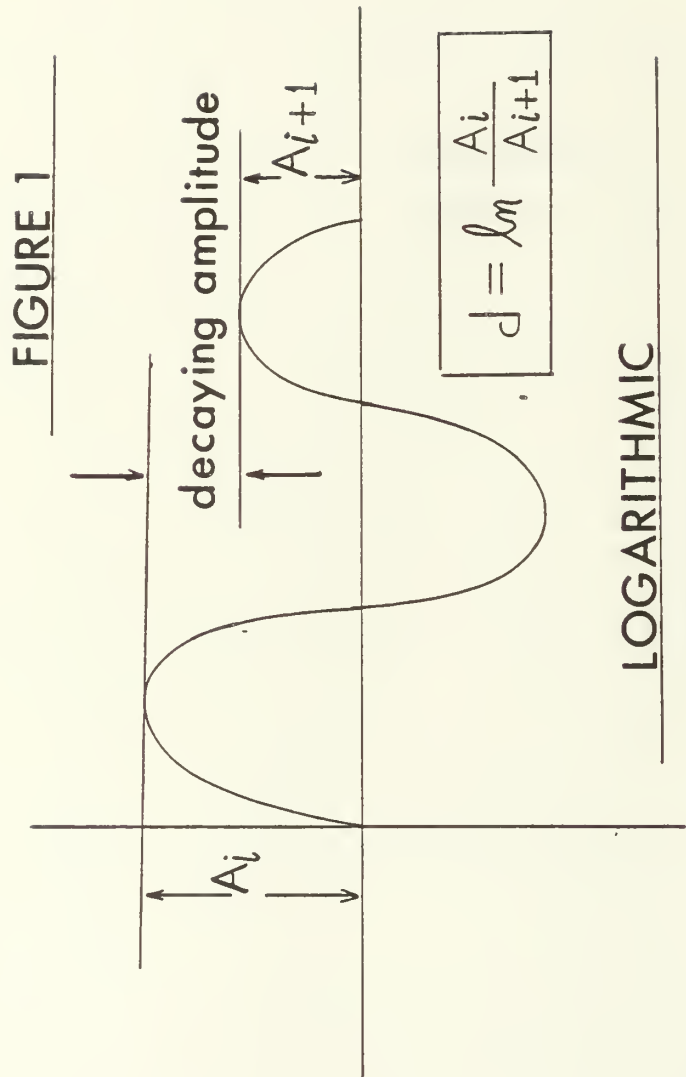
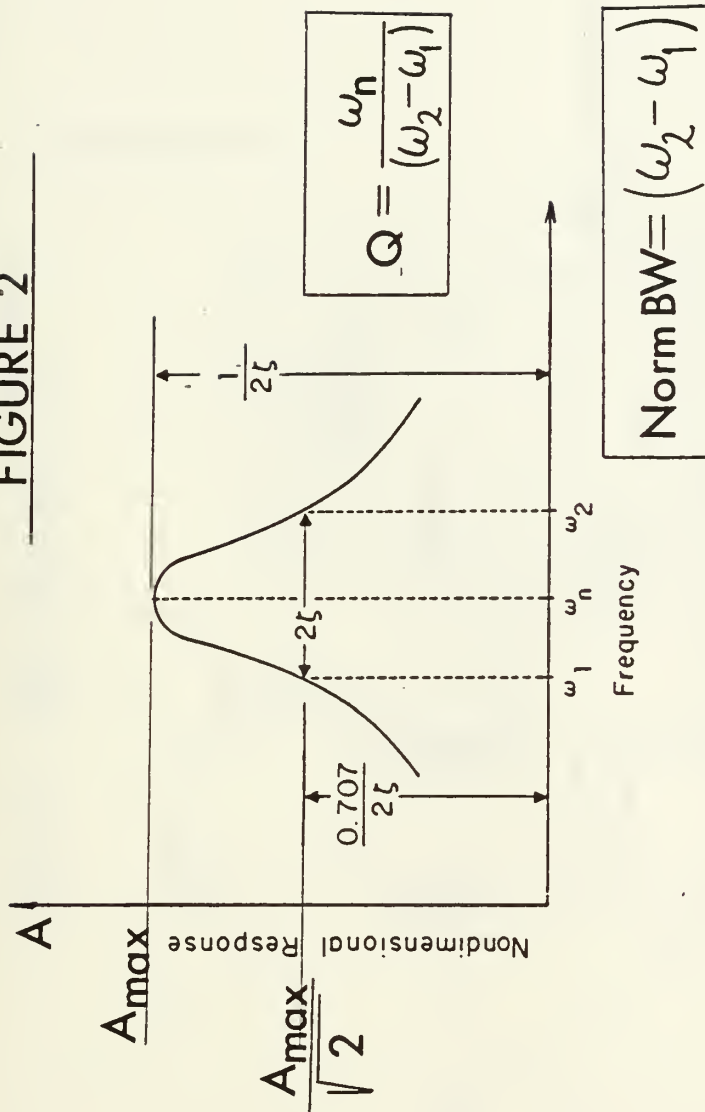


FIGURE 1 LOGARITHMIC DECREMENT

FIGURE 2



QUALITY FACTOR & NORM.

BANDWIDTH

FIGURE 2 QUALITY FACTOR & NORMALIZED BANDWIDTH

FIGURE 3

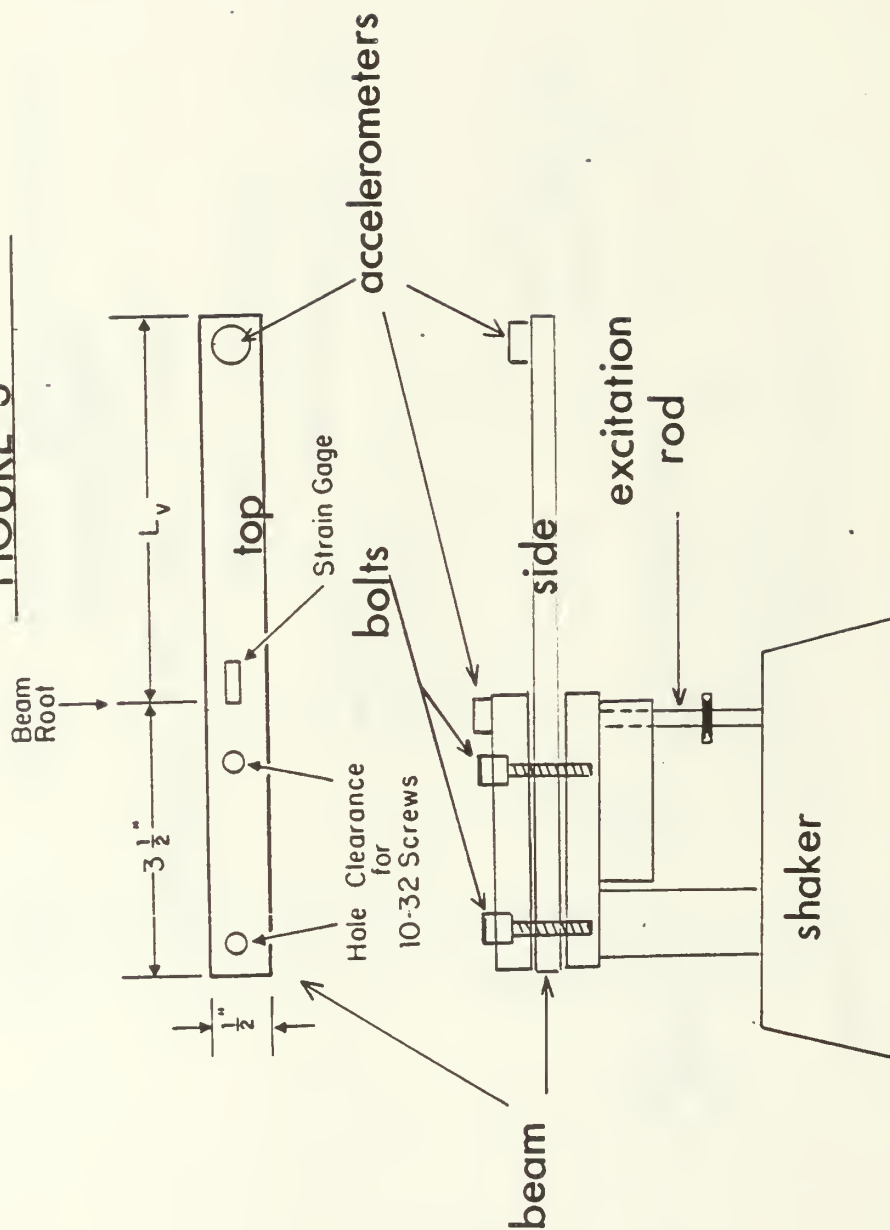


FIGURE 3 BEAM SPECIMEN & ITS POSITION ABOVE THE SHAKER APPARATUS

Cr-Fe (Chromium-Iron)

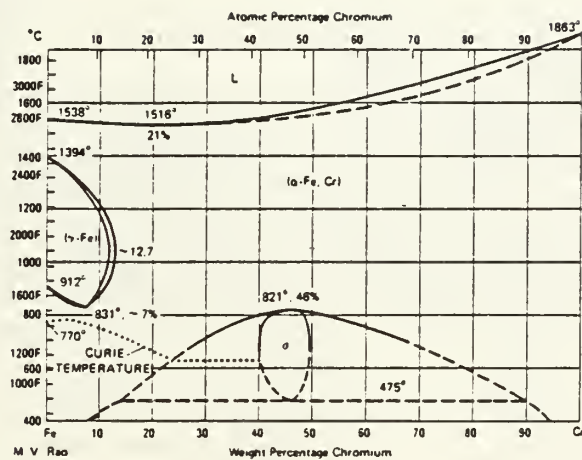


Figure 4 Phase Diagram of Iron-Chromium Binary System

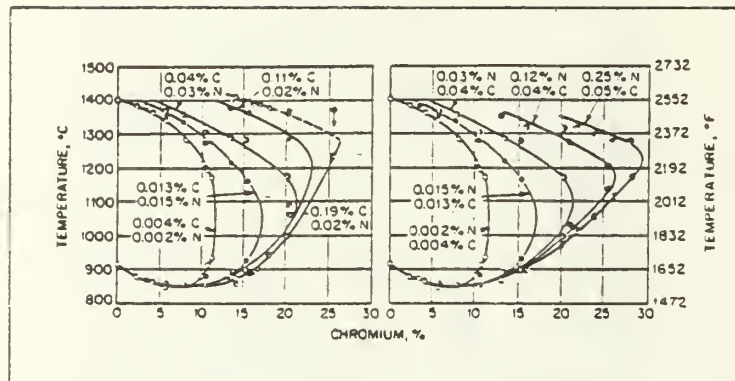


Figure 5 Shifting of the boundary line $(\gamma+\alpha)/\alpha$ in the Fe-Cr system through the addition of carbon and nitrogen

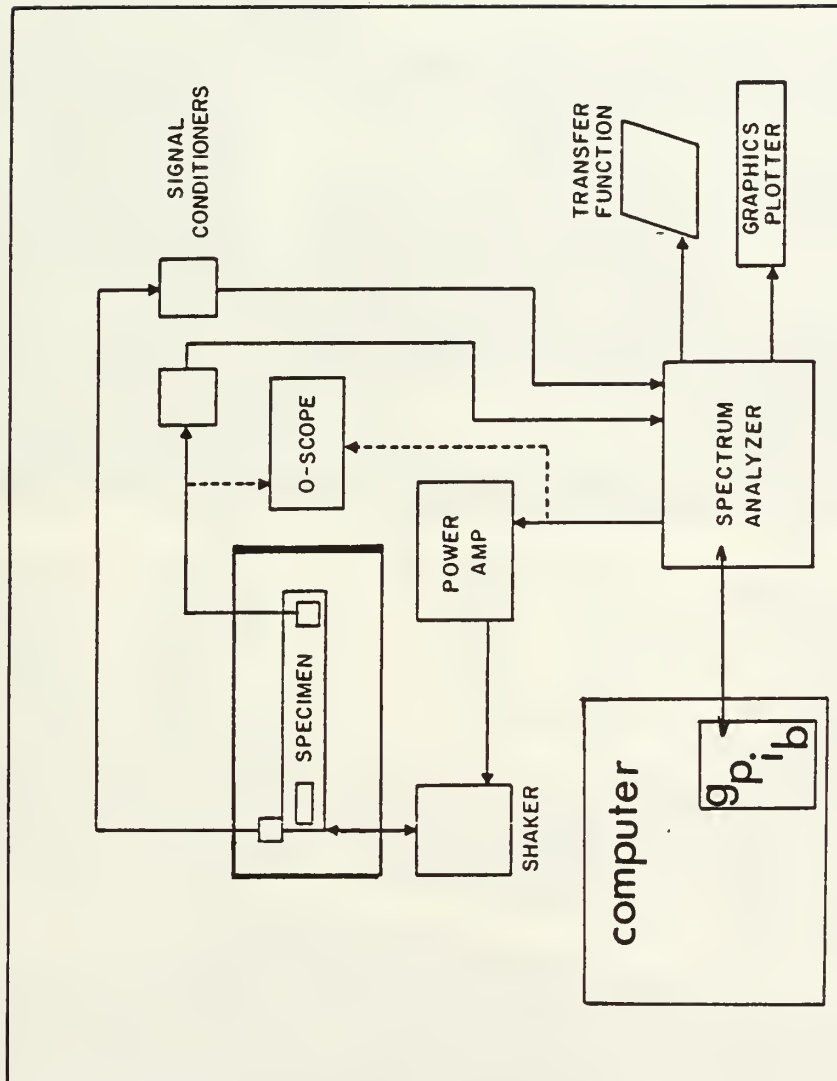


FIGURE 6

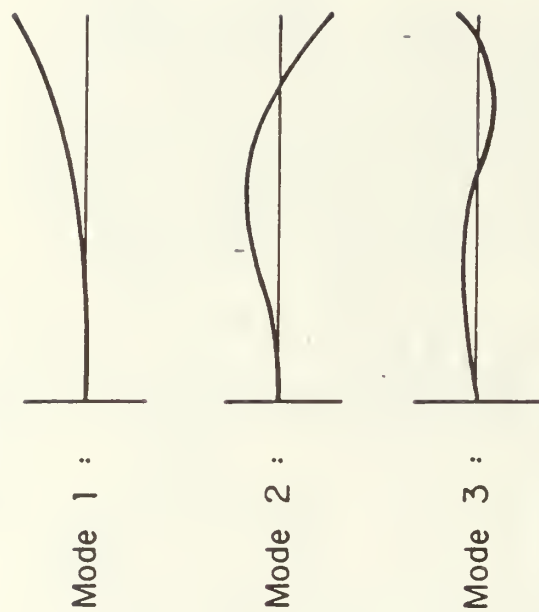


FIGURE 7
CANTILEVER BEAM: MODE SHAPES

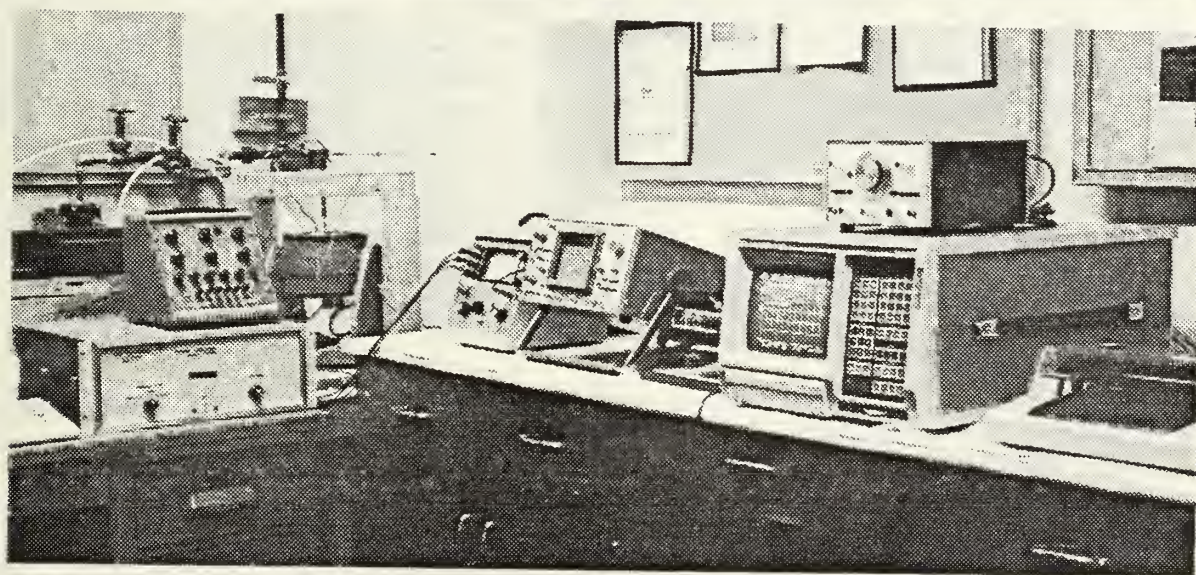
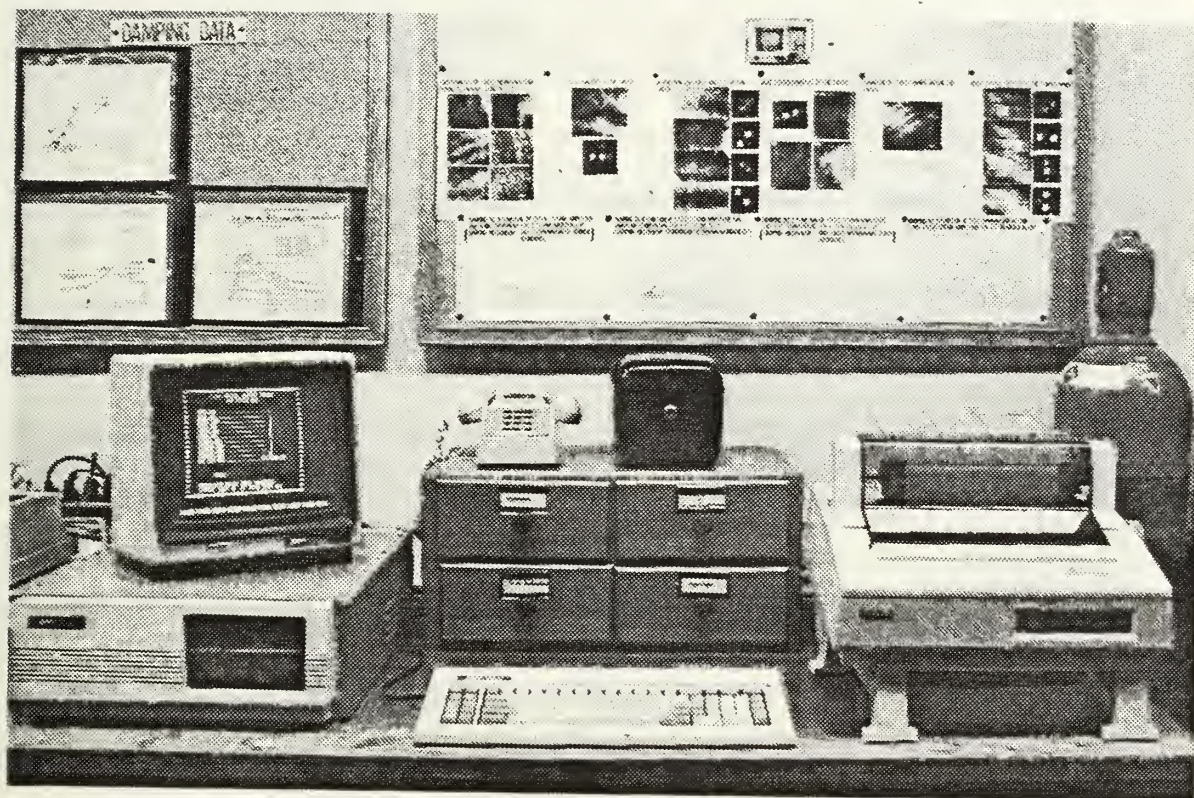


FIGURE 8 RESEARCH EQUIPMENT

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